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ABSTRACT

Many young women must contend with social and psychological barriers that prevent them from pursuing careers in science and mathematics. Because of lack of confidence, misconceptions, lack of preparation, and discrimination, many women self-select themselves out of as many as 75 per cent of all careers before they reach college age. This series was designed to inform and encourage women about careers in mathematics and science related careers. This guide provides resources related to the seven 30-minute and one 40-minute video programs in the series. Each episode includes: a program summary, introductory discussion questions, brief facts and statistics, a brief biography of a significant role model in the specific area of the episode, an interest assessment form, discussion questions to follow the program, descriptions of supplemental activities, lists of supplementary materials for students, and lists of resources for users and viewers. Program topics include: (1) biomedicine; (2) chemistry; (3) computer science; (4) dentistry; (5) engineering; (6) geosciences; (7) physicsand astronomy; and (8) scientific careers for women. (CW)

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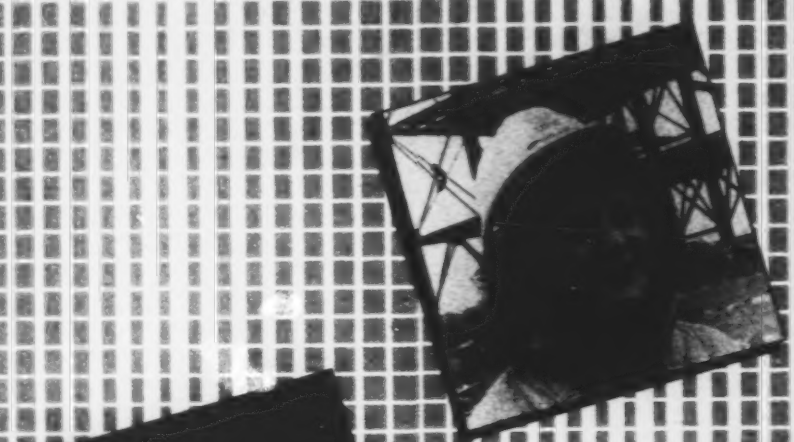
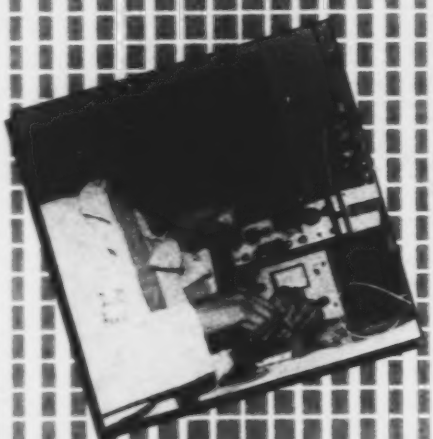
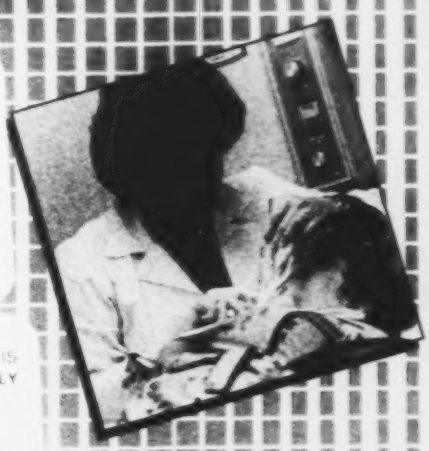
Women IN SCIENCE

RESOURCE GUIDE







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Resource Guide

Women in Science

A series of seven 30-minute and one 40-minute video programs
designed to encourage women to pursue careers in science.

Produced by the University of Michigan School of Dentistry

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- American Chemical Society
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- Association for Women Geoscientists

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Introduction

Why Is a Series on Women in Science Necessary?

Although the numbers of women entering fields traditionally dominated by men are increasing, women are still underrepresented in many areas, including science and engineering. While women today comprise 44 percent of all U.S. workers, they comprise only 15 percent of all scientists and engineers (National Science Foundation 1988).

Furthermore, the majority of undergraduate women who elect a science major tend to choose life and social sciences, sometimes referred to as the "soft" sciences. The supply of graduates with bachelor's degrees in these fields far exceeds the number of job opportunities.

Many young women must contend with social and psychological barriers that prevent them from pursuing careers in mathematics and science. Because of lack of confidence, misconceptions, lack of preparation, and discrimination, many women self-select themselves out of as many as 75 percent of all careers before they reach college age (Vetter 1982).

There is an obvious need for reconsideration and redirection in the academic training and career counseling of young women. By avoiding essential courses in high school, many young women deny themselves many exciting opportunities in college and beyond. Schools often perpetuate this dilemma by maintaining a passive role in the academic course selection and career decision-making processes of young women. Schools must help make female students aware of the opportunities for women in science, and encourage them to obtain a strong mathematics and science foundation.

What Are the Objectives of the *Women in Science* Series?

The series was designed to

- encourage women to explore career opportunities in fields of science that are considered nontraditional for women
- encourage women to select courses in mathematics and science in preparation for science-related careers
- inform students, parents, teachers, counselors, and administrators about opportunities for women in science
- address barriers that discourage women from seeking careers in science
- provide specific career information for each of the featured fields, including suggestions for academic preparation, descriptions of routine work, career options, and job opportunities
- provide women with role models who represent a variety of career paths in the sciences, as well as a variety of personal and professional lifestyles, ages, and ethnic backgrounds
- examine the realities of combining a career with family life

What Are the Barriers Encountered by Women Considering Careers in the Sciences?

Perhaps the most obvious barrier for young women considering careers in the sciences is the scarcity of female role models. Because women are underrepresented in many science career areas, they are usually not present in typical images of science and scientists, and therefore, not associated with science. Consequently, many young women do not consider science a realistic career option.

The series addresses five additional barriers.

- *By the time they graduate from high school, many women are academically deficient in mathematics and science.* This resource guide includes an overview of the general academic requirements for entrance into each of the featured fields. These materials should be duplicated for students. In each program, role models stress the importance and relevance of a strong mathematics and science education. Many of the featured women scientists address the issue of math anxiety, their initial fear of science courses, and how they overcame their fears.
- *Many women perceive women scientists and science careers as unattractive or unfeminine.* Smith (1978) suggested that

young women may feel that the "pursuit of these careers means loss of femininity." The presence of female role models in the programs reaffirms the appropriateness of women working in the sciences.

- *Many women perceive a role conflict between having a career in science and being a wife or mother.* Each program presents one or two professional women who are mothers of preschool or school-age children. They discuss issues such as dual-career marriages, division of domestic labor, and child care. Comments from husbands and children often reinforce the importance of understanding, support, and cooperation in dual-career marriages.
- *Many women lack job-seeking skills.* Preparation for the job market is one effective way to alleviate the anxiety women sometimes associate with job seeking. The series encourages women to obtain valuable academic credentials. The women featured in the series confirm that women can succeed in highly competitive, male-dominated fields if they are motivated and seek proper training as early as possible.
- *Many women experience discrimination.* Many young women are discouraged from pursuing science careers by significant individuals such as teachers, parents, counselors, and peers. This series provides a means of educating those who are unaware of the barriers that discourage women from pursuing mathematics and science.

Who Might Benefit from *Women in Science*?

The series is designed for junior high and high school-age women who are in the process of making career decisions and of selecting courses appropriate for their career goals. It is also designed to address counselors, administrators, teachers, parents, employers, college students, and women reentering the job market.

References

National Science Foundation. January, 1988. *Women and Minorities in Science and Engineering.* NSF 88-301.

Smith, Walter. April, 1978. Five Approaches to Increasing Participation of Talented Women in Science Centers. Presented at the National Science Teachers Association National Convention.

Vetter, B. M. 1982. *Opportunities in Science and Engineering.* Scientific Manpower Commission.

How to Use the *Women in Science* Series

While *Women in Science* was developed primarily for women in junior high and high school, it is also adaptable to a variety of audiences concerned with women's opportunities or science careers.

Each of the eight programs can be viewed separately or as part of a unit. When used in the classroom, the discussion questions, supplemental activities, and supplementary materials for students can be used to plan a short program, workshop, or longer unit.

The *Women in Science* resource guide contains the following materials for each program.

- **Program Summary**—a summary of program content and short biographies of the featured women scientists, in order of their appearance.
- **Before the Program**—discussion questions designed to orient and introduce viewers to relevant issues.
- **Did You Know?**—brief facts and statistics concerning the status of women in each of the featured fields of science.
- **After the Program**—discussion questions designed to help guide viewers through an in-depth discussion of relevant issues.
- **Supplemental Activities**—educational and motivational activities and projects designed to encourage viewers to explore their interests and aptitudes for each featured field of science.
- **Supplementary Materials for Students**—a guide for the viewer, including biographical profiles of contemporary women scientists; basic requirements for education and training; overviews of career options including specializations and work settings; overviews of economic outlook and salaries including information on potential for advancement, economic forecasts, and average salaries within each field.

  These materials are designed for duplication and distribution to viewers for classroom or personal use.
- **For More Information**—A resource list of organizations, publications, and other instructional materials relevant to each of the fields for users and viewers.

About Program 8: "Scientific Careers for Women: Doors to the Future"

Program 8 is designed to help counselors, parents, teachers, and students become more aware of the wealth of career opportunities available in the sciences while examining some of the barriers that discourage young women from pursuing these careers. It can be used as an introduction or conclusion to a course or workshop on women's opportunities or science careers.

Program 8 can be used with a variety of audiences to

- review the issues associated with the entry of women into nontraditional careers in the sciences
- explore the roles of teachers, counselors, school administrators, peers, and parents in encouraging women to pursue mathematics and sciences
- inform and motivate young women to elect mathematics and science courses

Suggestions for the User

- Preview the program(s), if possible.
- Review the appropriate sections of the resource guide.
- Duplicate supplementary materials for individual viewers.
- Review and plan supplemental activities in advance.

Program 1
Biomedical Fields

Program Summary

The program describes biomedicine as a complex group of interrelated specialties that combine basic scientific research and medicine. Biomedical professionals usually hold bachelor's degrees in one of the basic sciences such as biology, chemistry, and physics. They often hold advanced degrees in science, engineering, or medicine.

The narrator explains that the common goal of biomedical professionals is to improve human health and life. The professionals featured in this program often work in teams with other specialists, applying their expertise to challenging problems such as perfecting a new treatment for a diseased bone, developing safety equipment and procedures to protect industrial workers from toxic chemicals, or developing a new medicine for diabetes.

The program presents women who have successfully established careers in biomedical fields, and students who are currently pursuing careers.

In order of appearance

- **Irene Jones** holds a Ph.D. in genetic toxicology. She develops tests that help to determine the effects of chemical exposure on human genes.
- **Beth Concoby**, an industrial hygienist with a Masters of Public Health, develops, evaluates, and reviews regulations which protect employees and consumers from exposure to harmful chemicals or conditions.
- **Janet Ku**, a bioengineering doctoral student, investigates the potential of a technique for replacing sections of diseased bone with healthy bone material.
- **Judy Clark**, a bioengineering graduate student with a special interest in nuclear medicine, uses PET scanning[1] to observe brain functions in humans.
- **Joyce Vargyas**, an obstetrician-gynecologist with an M.D. degree, specializes in *in vitro* fertilization.[2]
- **Jessica Schwartz**, Ph.D., manages a research laboratory at the University of Michigan Medical School. Her specialty is physiology.
- **Joyce Essien**, M.D., specializes in pathology. She directs the Laboratory Program Office at the Centers for Disease Control (CDC) in Atlanta.
- **Carey Callaway** is an electron microscopist at CDC. She holds a B.S. and a specialty degree in electron microscopy.
- **Shirley Maddison**, Ph.D., is a parasitologist at CDC who specializes in diseases common in Third World countries.
- **Diane Rowley**, M.D., studies the distribution and dynamics of disease at CDC.
- **Alice Istock** is a student majoring in biology.

Many of the scientists featured in the program mention the rewards of research and the excitement of discovery. Others talk about the satisfaction they derive from working to improve the health of their patients.

The program reviews recommendations for high school and college preparation. High school students should develop a strong background in mathematics and science. A bachelor's degree in biology, chemistry, computer science, engineering, or physics could lead to advanced study and training in many biomedical fields.

Professionals in biomedicine work in patient care and clinical application, research and development, administration, or a combination of these areas. As technology advances, the demand for biomedical professionals increases.

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[1] PET is the abbreviation for Positron Emission Computed Tomography, a scanning method used in diagnostic medicine, especially in work on the brain.

[2] *In vitro* fertilization is a method of artificial fertilization. Sperm is introduced to the egg outside the mother's body in an artificial environment such as a test tube. Once fertilization occurs, the egg is returned to the mother's body, where normal fetal development can proceed.

Did You Know?

- The numbers of health personnel in all fields have continued to increase through the mid-1980s (U.S. Department of Health and Human Services, March 1986).
- There have been significant increases in the numbers of females in medical professions that traditionally have been male-dominated (U.S. Department of Health and Human Services, March 1986).

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Biomedical Fields Interest Assessment on page 8, and then proceed with an introductory discussion.

1. What types of work might a scientist in biomedicine perform?
2. What kind of person might be attracted to these fields?
3. What type of education is necessary?
4. What is the minimum degree that most biomedical professionals earn? (A master's degree or M.P.H. [Master of Public Health] is usually necessary to perform laboratory or clinical work. A master's degree or doctorate is usually necessary for conducting research.)
5. Which courses would best prepare a high school student interested in a career in biomedicine? (mathematics, science, English, communications, foreign language)
6. What type of major should a college student interested in biomedicine choose? (physical sciences, mathematics, premedicine)
7. Why is it advisable for high school students interested in biomedicine to take as many mathematics and science courses as possible? (Avoiding them may make it difficult to catch up in college, where familiarity with the essential concepts of mathematics and science is essential.)
8. Can women in biomedicine satisfactorily combine their careers with motherhood? (While combining a professional life and family life is demanding, it is probably no more difficult for women in biomedicine than for those in other professions. Many of the professionals featured in the program are mothers.)

After the Program

Possible answers to the following discussion questions are in parentheses.

1. Which aspects of the featured careers in biomedicine did you find most attractive? (interaction with other people, promoting health, discovering new medicines and treatments, meaningful work, good employment prospects and salaries, helping others, variety of job options)
2. Describe some types of work that biomedical scientists perform. (patient care, developing life-preserving machines, researching the effects of chemicals on humans, teaching, developing new medicines, investigating the sources and cures for diseases, assisting in laboratory procedures)
3. What are some of the settings in which biomedical scientists work? (hospitals, laboratories, classrooms, industries, government agencies, on location for industries or government)

Supplemental Activities

1. Invite local biomedical professionals and students to discuss their career training and experiences with your class or group.
2. Arrange for students to meet and question a variety of biomedical professionals in a typical work environment such as a hospital or university. A hospital public relations manager or college admissions counselor might help organize the event. Have students write reports about their experiences.
3. Keep a biomedicine bulletin board and career file. Have students contribute to the collection of current developments and career opportunities. Share this information with other classes, counselors, librarians, and teachers, and encourage them to be aware of these and other nontraditional career opportunities for women.

4. Coordinate a "shadow" program for high school students. "Shadowing" a woman biomedical professional for part or all of one day will enable students to gather firsthand information and impressions.

5. Have one student role-play a prospective science major. Another student can role-play a college admissions counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in science. Discuss and role-play methods of coping with direct and subtle discouragement.

6. Contact local colleges for information on programs such as science department career fairs, open houses, symposiums, and internships. Encourage students to participate. These activities help students learn to work independently, develop their own innovative research projects, conduct research, and present results.

7. Schedule a field trip. Options may include an immunization clinic, county public health department, hospital laboratory, blood bank or blood laboratory, or family planning agency. Research laboratories often are receptive only to very small groups.

8. Sponsor a bloodmobile. Help students initiate, organize, and assist with this community service.

9. Students can learn about the human body in class by performing simple tests: reflexes, lung capacity, blood pressure, pulse, urine analysis, and blood typing. Incorporate these activities into a unit in a regular biology or science class.

10. Make arrangements for students to watch a demonstration of diagnostic testing and equipment such as Electroencephalograph (EEG), Electrocardiograph (EKG or ECG), vital capacity test, glucose tolerance test, glaucoma test, CAT scan, X-ray, and radiation treatment. Help students notice the importance of computers in a wide variety of diagnostic processes.

11. Incorporate computers into the classroom. A variety of relevant software is available for use in science classes.

Supplementary Materials for Students

Outstanding Women in Science: Biomedicine

Occupation: Emeritus Professor of Medicine, University of Alabama; Distinguished Physician, Veterans Administration, Birmingham, Alabama.

Education: M.D., College of Medicine, University of Vermont, 1944.

Awards and honors: American Heart Association, Gold Heart Award, 1979 and Distinguished Achievement Award, 1980; National Conference on High Blood Pressure Control, Edward D. Freis, M.D. Award, 1985; American Medical Association, Scientific Achievement Award, 1987.

Professional service: President, American Heart Association, 1976-77; Board of Regents, American College of Physicians; Member, National Academy of Sciences.

Harriet P. Dustan

Dr. Harriet P. Dustan is a cardiovascular and hypertension specialist who studies the role of salt in high blood pressure. She is director of the General Clinical Research Center at the University of Alabama Hospital, where she treats and studies high blood pressure patients.

Dr. Dustan began her studies in the 1940s, when medicine was predominately a male profession. "My grandfather and great-grandfather had been physicians in the small Vermont town in which I was brought up, and this made it acceptable for me to choose medicine," she explains. "My only brother died of subacute bacterial endocarditis when I was 11 years old, and that firmed my decision to become a physician."

She received support and encouragement from a mentor, Dr. Irvine H. Page, at the Cleveland Clinic in Cleveland, Ohio, where she began her research career. "He sheltered me in a highly competitive world, afforded me opportunities, stimulated me to contribute, and was probably the best professional friend I ever had," she says.

Dr. Dustan joined the permanent staff of the Cleveland Clinic in 1951 and continued her work in hypertension and high blood pressure there for 26 years.

"Be serious," Dr. Dustan advises young women considering careers in biomedicine. "If you are interested in research, be sure that you get training in basic research disciplines."

Of her many accomplishments, Dr Dustan feels most proud of her research contributions to the understanding of high blood pressure due to kidney disease and of her investigations into new drug treatments for hypertension. "What I like best is contributing to society," Dr. Dustan says. "As a doctor, one cherishes what one can give."

Biomedical Fields Interest Assessment

The following questions reflect some of the common interests of biomedical professionals. If you answer yes to many of these questions, you might want to consider a career in biomedicine.

---

1. I find the following occupations attractive: chemist, computer programmer, engineer, nurse.

   Yes _____ No _____

2. I enjoy courses such as: algebra, biology, chemistry, physics, physiology, and statistics.

   Yes _____ No _____

3. Helping people will be an important factor in my career choice.

   Yes _____ No _____

4. I like conducting scientific experiments.

   Yes _____ No _____

5. I enjoy the challenge of finding different ways to solve a problem.

   Yes _____ No _____

6. I am willing to work with others. I genuinely like people.

   Yes _____ No _____

7. I like assignments that require gathering and recording information.

   Yes _____ No _____

8. When I have a job to do, I plan a course of action and then follow through with my plan.

   Yes _____ No _____

9. I would enjoy a job that requires me to keep abreast of the newest scientific technologies and advances in my field.

   Yes _____ No _____

10. I sometimes think of new inventions or products that would help people.

    Yes _____ No _____

11. When I have a problem to solve, I stick with it.

    Yes _____ No _____

12. I am generally interested in the field of health.

    Yes _____ No _____

Career Options in Biomedical Fields

Biomedicine is a very broad term that encompasses many areas of science, medicine, and engineering. Nursing and the allied health occupations have been the traditional domain of women in biomedicine, but more and more women are moving into other areas. Many of the following careers represent nontraditional career opportunities for women.

Biologists study living organisms and the relationship of animals and plants to their environment. Some biologists are involved in research to increase basic knowledge of living organisms; others in applied research use this knowledge in activities such as developing new medicines, increasing crop yields, and improving the environment.

Biochemists study the complex chemical combinations and reactions involved in metabolism, reproduction, growth, and heredity.

Medical microbiologists study the relationship between bacteria and disease or the effect of antibiotics on bacteria. Some specialize in virology (the study of viruses), or immunology (the study of mechanisms that fight infections).

Biomedical engineers combine medical knowledge and basic science and technology to design and build medical instrumentation and devices such as artificial organs and limbs. Computers are often used to help design and monitor such equipment.

Some biomedical engineers study materials such as plastics, metals, and other substances to explore their potential utility in the development of new biomedical technology (Swanson 1984, 17).

Biomedical equipment technicians, also called **bioengineering technicians**, install, calibrate, inspect, and perform general maintenance and repair on biomedical instruments and equipment and related technical equipment. They are generally knowledgeable about the design, function, and clinical application of biomedical equipment and often teach or demonstrate the function and operation of such equipment to other health care personnel (Swanson 1984, 18).

Biomedical scientists conduct research in a variety of medical specialties and in a variety of settings such as hospitals, government laboratories, and universities. These research specialists often work in teams with other types of specialists to solve complex medical problems. Some areas of medical specialization are

- **Bacteriology**—the study of bacteria
- **Cytology**—the study of cells
- **Endocrinology**—the study of the endocrine glands and their secretions (hormones)
- **Epidemiology**—the study of epidemic diseases
- **Hematology**—the study of blood and blood-forming organs
- **Histology**—the study of tissues
- **Parasitology**—the study of parasites
- **Pathology**—the study of diseases
- **Pharmacology**—the study of drugs
- **Physiology**—the study of living organisms
- **Serology**—the study of blood serum
- **Toxicology**—the study of poisons

Clinical engineers use engineering concepts and technologies to manage and improve health care delivery systems in hospitals, clinics, and other environments (Swanson 1984, 18).

Genetic engineers specialize in methods of manipulating genetic material to improve human life and health. Artificial insemination is probably the best known example of genetic engineering.

Genetic scientists are biomedical scientists concerned with the way genes operate and how genetic material affects physiological reactions within cells.

Genetic toxicologists are concerned with the effects of toxic materials on human populations.

Industrial hygienists are biomedical scientists who work to eliminate environmental hazards in industrial settings. They are concerned with reducing or eliminating worker exposure to toxic chemicals, heat, noise, dust, and other hazardous conditions.

Medical practitioners are involved in diagnosis, treatment, and prevention of illness and disease. Practitioner specialties include anesthesia, dermatology, ear/nose/throat, emergency practice, family practice, gynecology/obstetrics, immunology, internal medicine, neurology, ophthalmology, pathology, pediatrics, physical medicine, psychiatry, public health, radiology, and surgery.

Medical technologists culture specimens and perform tests that provide vital information to other medical professionals about the presence of specific diseases and other abnormalities in the human body. Some medical technologists specialize in areas such as biochemistry, blood bank technology, cytotechnology, hematology, and parasitology (Swanson 1984, 127).

Work Settings

Biomedical professionals often work in

- *government institutions* such as federal research laboratories, state and local departments, commissions, and health regulatory agencies
- *health care facilities* such as hospitals, clinics, medical centers, health maintenance organizations, and private offices
- *industry* in areas such as applied research and testing, production, quality control, and technical writing
- *institutions of higher education* such as colleges, universities, and medical schools
- *private corporations and nonprofit foundations*

Preparing for a Career in a Biomedical Field

Biomedicine offers a large variety of career options for students interested in health and science. A strong background in basic mathematics and science is necessary for students who wish to explore these options.

While grades aren't the only determining factor in gaining admission to undergraduate and graduate schools, they are important and can help students obtain college scholarships and financial aid.

Some scholarships and fellowships are available exclusively to women and minorities. Students might contact college admissions offices and professional medical organizations for more information.

The following recommendations should help students direct their studies toward biomedicine.

Secondary Education

High school students interested in the biomedical fields are encouraged to focus on a mathematics and science curriculum in addition to a well-rounded education.

Mathematics—Suggested courses are algebra, geometry, trigonometry, calculus, and statistics.

Sciences—Students are advised to select a strong sequential program in science. Courses in biology, chemistry, physics, physiology, and zoology will be advantageous.

English and communications—Courses in these curriculum areas help students develop writing, speaking, and other skills which enable them to communicate effectively with patients and colleagues.

Modern foreign languages—Students should select a language sequence, preferably in French, German, Russian, or Spanish. Language proficiency is necessary for biomedical professionals who often participate in international gatherings and follow research advances reported in foreign journals.

Additional course work—*Computer science*: Computer literacy and experience in programming will be advantageous as computers become more and more integral in biomedicine. *Social sciences:* Familiarity with the fields such as sociology, psychology, and anthropology is important for scientists concerned with human life and health.

Postsecondary Education

There are many courses of study and combinations of degrees available for students of biomedicine. Students usually must continue beyond the bachelor's degree in order to secure a position with a high degree of responsibility or leadership.

Mathematics and science majors should not overlook the importance of general liberal arts studies. Students should take courses in the humanities, particularly in communications, languages, philosophy, and writing.

Associate degree—Many one- to two-year allied health programs are offered by community and junior colleges and hospitals. These programs combine classroom and laboratory study with clinical practice. Graduates receive certificates or associate degrees enabling them to qualify for positions as technicians.

Bachelor of Science (B.S.)—The bachelor's degree requires four years of college. Students interested in positions as technologists often complete specialized four-year training programs which require extensive laboratory work. Students who intend to pursue an advanced degree and who plan to specialize in one area should consider majoring in a basic science such as biology, chemistry, physics, statistics, or engineering.

Master of Science (M.S.)—The master's degree requires two to three years of study beyond the bachelor's degree. Specialized graduate school programs are comprised of advanced courses, research within an area of interest, and completion of a thesis. The master's degree is sufficient for positions in applied research.

Doctor of Philosophy (Ph.D.)—This degree involves three to six years of study beyond the bachelor's degree and doctoral research. Students must conduct an independent investigation presented in the form of a dissertation. A doctorate is generally required for college teaching and independent research.

Doctor of Medicine (M.D.)—Minimum education requirements beyond a bachelor's degree for prospective physicians include a four-year program of medical education followed by at least three years of training (residency or internship). Physicians who specialize in a particular area must also qualify for board examinations upon completing their residencies.

Outlook and Salaries

The employment outlook for individuals in biomedical fields is expected to remain favorable. Several factors account for the anticipated growth in biomedical careers and are expected to continue to influence the innovation and direction in the field. Those factors include

- the ongoing advances and continuing demand for developments in biomedical engineering and computing
- the critical importance of laboratory tests in the diagnosis and treatment of health problems
- the increasing demand for diagnostic tests due in part to the increasing number of health insurance plans which include comprehensive coverage of diagnostic tests and to the growing availability of health insurance plans for employees
- the recent research advances in the areas of genetics and biochemistry and the subsequent increases in funding for research and development in these and other specialized areas
- the initiation of legislation focusing on the dangers of exposure to harmful toxins in the environment
- the anticipated population growth and the projected increase in elderly patients
- the increase in fitness consciousness, participation in fitness activities, and broadening concern for health improvement

The average salaries and employment projections for some biomedical careers are listed below. Unless a specific reference notation is given, the salary and employment projections were obtained from the U.S. Department of Labor Statistics *Occupational Outlook Handbook*, 1986-87 edition.

Biological scientists

In 1987, the average starting salary offered to a biological scientist with a bachelor's degree was $18,132 (College Placement Council, March 1987). Many graduates with advanced degrees and experience earn considerably higher salaries.

Due to recent advances in genetic research, the employment outlook for biological scientists is expected to increase 11–19 percent, about as fast as average for all occupations through the 1990s. Advances in biotechnology should lead to many additional research jobs. Employment opportunities will be better for those with advanced degrees and will vary by speciality. Those who specialize and conduct research in genetic, cellular, and biochemical biology should have the best opportunities.

Chemists

In 1987 the average starting salary offered to a chemist with a bachelor's degree was $26,736 (College Placement Council, March 1987). Many with advanced degrees and experience earn considerably higher salaries in the biomedical fields.

While the general growth of jobs in chemistry is expected to decline through the 1990s, the majority of new job openings will be in biomedical fields.

Medical technologists

In 1984 the average salary for medical technologists working in hospitals, medical schools, and medical centers was $18,200. Those with advanced degrees and experience averaged $23,700. Chief medical technologists employed in hospitals earned an average of $25,300–$31,000 in 1985.

The federal government paid medical technologists an average salary of $14,400, and those with a year of graduate study earned $17,800 in 1985.

Employment for all clinical laboratory workers is expected to grow 4–10 percent, more slowly than the average for all occupations through the mid-1990s. Efforts to contain and reduce health care costs are expected to contribute significantly to the slowdown in growth. However, medical technologists will still be needed.

Biomedical engineers

Salaries vary significantly according to an individual's work environment and qualifications. In 1984 the average salary range was $18,500–$22,000 for those with a bachelor's degree; $22,000–$27,000 for those with a master's degree; and $28,000–$42,000 for those with a doctorate. Highly skilled and experienced engineers with management experience earn considerably more (Swanson 1984).

According to Easton (1986), careers in biomedical engineering are expected to flourish. While the majority of the approximately 4,500 biomedical engineers in 1984 were men, more women are gradually entering the field. The demand for biomedical engineers exceeds the supply, and the number of jobs is expected to grow by 25 percent through the early 1990s (Swanson 1984).

Biomedical equipment technicians

In 1984, biomedical equipment technicians with two-year associate degrees earned an average starting salary of $12,000–$16,500. Certified technicians with four years of experience averaged $17,500–$23,500. Certified technicians with advanced experience averaged $28,300–$36,000 (Swanson 1984).

The demand for biomedical equipment technicians is expected to increase through the 1990s.

Medical practitioners

In 1984, medical school graduates in residencies earned average salaries of $20,000–$24,000. Graduates having completed three-year residencies but having no other experience averaged $44,400 in 1985 at Veterans Administration hospitals.

In 1984, the average income of all physicians was $108,400. Employment for health practitioners is expected to remain favorable through the mid-1990s. However, according to the *Occupational Outlook Handbook*, "the market is changing as supply overtakes demand. The physician shortage identified during the 1960s and early 1970s has vanished as a result of legislative measures designed to expand supply."

Despite this trend, the demand for physicians is expected to continue to grow as the current population ages.

For More Information

Associations and Organizations

American Medical Women's Association, 465 Grand St., New York, NY 10002; 212/533-5104.

Association for the Advancement of Medical Instrumentation, 1901 North Fort Myer Drive, Suite 602, Arlington, VA 22209-1699.

Biomedical Engineering Center, Ohio State University, 2015 Neil Ave., Columbus, OH 43210; 614/422-6018.

Biomedical Engineering Society, P.O. Box 2399, Culver City, CA 90231; 213/206-6443.

National Institutes of Health, Division of Public Information, 9000 Rockville Pike, Bethesda, MD 20892; 301/496-5787.

National Institutes of Health, National Library of Medicine, 8600 Rockville Pike, Bethesda, MD 20894; 301/496-6308.

Women in Cell Biology, contact Dr. Alina Lopo, Department of Biological Chemistry, University of California School of Medicine, Davis, CA 95616; 916/752-3310.

Publications

Easton, Thomas. *Careers in Science.* Lincolnwood, Illinois: VGM Career Horizons, a division of National Textbook Company, 1986.

Eron, Carol. *The Fast Track to the Top Jobs in New Medical Careers*. New York: Pedigree Books, The Putnam Publishing Group, 1984.

Swanson, Barbara. *Careers in Health Care*. Homewood, Illinois: Dow Jones–Irwin, 1984.

References

College Placement Council. March 1987. *Salary Survey*. Formal Report No. 2.

Easton, Thomas. 1986. *Careers in Science*. Lincolnwood, Illinois: VGM Career Horizons.

National Science Foundation. January 1986. *Women and Minorities in Science and Engineering*.

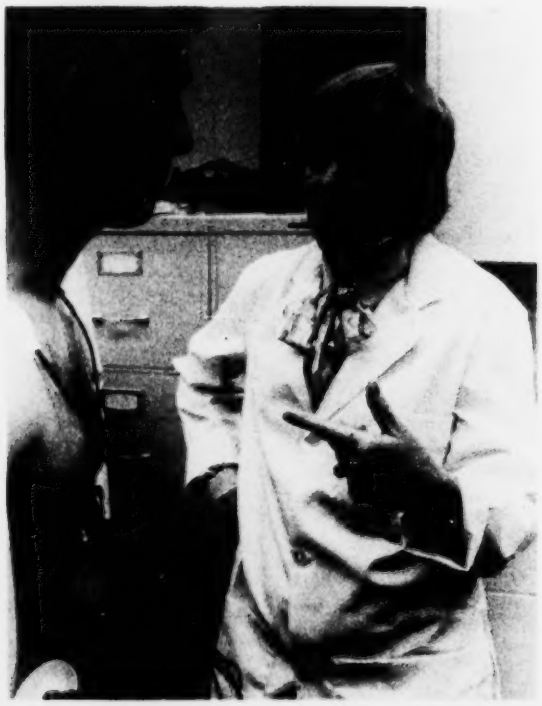
Swanson, Barbara. 1984. *Careers in Health Care*. Homewood, Illinois: Dow Jones–Irwin.

U.S. Bureau of Labor Statistics. 1986. *Occupational Outlook Handbook*. Washington, DC: Government Printing Offices. 1986-87 edition. Bulletin 2250.

U.S. Department of Health and Human Services Bureau of Health Professions. March 1986. *Fifth Report to the President and Congress on the Status of Health Personnel in the United States*.

Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

A graduate student in neurochemistry examines a tissue sample to learn more about the behavior and function of neurotransmitters in the brain.



A biomedical engineer describes a diagnostic procedure to a patient.

Program 2
Chemistry

Program Summary

The narrator names a variety of products that are taken for granted in contemporary life, including plastics, permanent press clothing, jet fuel, toothpaste, fertilizer, shatter-proof glass, perfume, and latex paint. Chemists have contributed to the development of these and countless other essential and luxury items used on a daily basis in our society.

The chemists featured in the program explain how and why chemistry plays an integral part in many kinds of scientific research. Chemistry is often a principal factor in the development of technological advances that transform modern medicine, industry, agriculture, and many other aspects of society.

Chemists work in an enormously diversified field, doing research on products, developing new medicines, analyzing compounds, teaching, even restoring works of art and archaeological finds.

Chemists often work in universities, hospitals, government agencies, private industry, and many other settings.

The program focuses on six women who have chosen chemistry as a career.

In order of appearance

- **Jeannette Brown**, M.S., specializes in inorganic chemistry. She works for a private research laboratory developing compounds which may be used eventually as pharmaceutical products.
- **Donna Metzger**, M.S., is a forensic chemist with the Illinois Department of Law Enforcement Scientific Services Bureau. She examines evidence in criminal cases.
- **Karen Morse**, Ph.D., heads the Department of Chemistry and Biochemistry at Utah State University. She combines her administrative duties with research.
- **Helen Free**, Director of Marketing Services at Miles Laboratories, holds a bachelor's degree in chemistry and a master's degree in management.
- **Kristin Peterson** and **Barbara Ruppel** are students majoring in chemistry.

The chemists featured in the program often mention the satisfaction and excitement of working in a challenging field in which important, life-enhancing discoveries are made frequently. Some appreciate the creative nature of chemistry; others enjoy the variety of tasks involved in their careers.

The program reviews recommendations for high school and college preparation for chemistry careers. High school students should develop a strong background in chemistry, physics, and mathematics. College students working toward a bachelor's degree in chemistry usually take two years of introductory and general college course work, and then concentrate mainly on advanced chemistry courses and laboratory work. Many students take advanced degrees, specializing in one area of chemistry; others go into related fields.

Did You Know?

- Women now comprise an increasingly larger fraction of the chemistry profession. In 1985, 15 percent of all members of the American Chemical Society working in the U.S. were women. In 1980, 10 percent of all ACS members were women and less than 8 percent in 1975 (ACS 1986, 64:17).
- In recent years, one-third of all bachelor's degrees in chemistry were awarded to women, as compared with less than 20 percent in the 1960s and 1970s (ACS 1986, 64:17). In 1986, 21 percent of all Ph.D. degrees in chemistry were awarded to women (ACS 1985, 63:30).
- Women chemists tend to be markedly younger and therefore less experienced than their male counterparts, due to the increasing numbers of women who have recently entered the profession. Nearly 60 percent of women, but only 30 percent of men, earned their bachelor's degrees in chemistry less than 15 years ago (ACS 1986, 64:26).

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Chemistry Interest Assessment on page 18, and then proceed with an introductory discussion.

1. What types of work might chemists perform?
2. What type of education is necessary?
3. Look at various objects around the room. Which ones were manufactured with the help of chemicals or chemical processes?
4. What kind of person might be a successful chemist?

After the Program

Possible answers to the following discussion questions are in parentheses.

1. Why should a student thinking about a career in chemistry acquire a strong background in high school mathematics? (Because mathematics skills are required for acceptance into college chemistry programs. Mathematics is essential in chemistry studies.)
2. What are some of the career options available to chemists? (administration, development, applied research, basic research, marketing, teaching)
3. Does combining a career in chemistry with marriage require special effort? (The program mentions the importance of mutual support, shared responsibility, and commitment in dual-career marriages.)
4. What characteristics should a chemist possess? (talent for assembling or making things, curiosity about how things are made, patience, good dexterity and hand-eye coordination, perseverance)
5. How might chemistry students gain valuable work experience while still in school? (internships, co-op experiences, assisting professors on research projects, summer jobs in laboratories or hospitals)
6. What kinds of courses are included in an undergraduate chemistry program? (mathematics, chemistry and physics, languages, social sciences, humanities)
7. Why must chemists possess effective communication skills? (Scientific progress often involves interaction and communication among researchers. Chemists' responsibilities often include written and oral reports and grant writing.)
8. What are some of the appealing aspects of a career in chemistry? (the opportunity to be creative, a variety of responsibilities, the opportunity for discovery, the potential to make important social contributions, the challenge of problem-solving)
9. What purpose does an advanced degree in chemistry serve? (Advanced degrees lead to jobs that require more expertise and responsibility and offer better salaries. Advanced degrees are also necessary for teaching in colleges or universities. In addition, advanced degrees lead to a variety of specializations such as forensic chemistry or toxicology.)

Supplemental Activities

1. Invite local chemistry professionals and students to discuss their training and job experiences with your class or group.
2. Encourage students to form a chemistry club. Help them make decisions about activities, projects, and speakers.
3. Organize a field trip to a chemistry laboratory in a hospital, university, or industry, or plan a series of field trips to several different laboratory settings.
4. Keep a bulletin board or scrapbook with information on notable women chemists and on new advances in chemistry. Share this information with other classes, counselors, librarians, and teachers, and encourage them to be aware of these and other nontraditional career opportunities for women.
5. Have one student role-play a prospective science major. Another student can role-play a college admissions counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in chemistry. Discuss and role-play methods of coping with direct and subtle discouragement.

6. Arrange an activity that enables students to test their skills in forensic chemistry. Present clues (hair, coat cloth fibers, etc.) to the identity of a "mystery student." (Select a volunteer beforehand.) Challenge student teams to use the evidence provided to determine the identity of the mystery student.

7. Suggest that students role-play a dual-career couple at home. They should decide how the cooking and household chores are to be divided and accomplished.

8. Gather information about science fairs and competitions directed toward your class level. Encourage students to create and submit chemistry projects to these competitions. Encourage them to collaborate on projects whenever appropriate.

9. Investigate summer programs, camps, and institutes that might enable students to get a head start in chemistry studies. Information on local programs for young scientists may be available from school boards, colleges and universities, or chemists' associations.

10. Perform an experiment.[1] The experiment below is designed for inexperienced students. Develop or choose a more advanced experiment for chemistry students.

    Ask students to test different substances to discover whether they are acidic, alkaline, or neutral.

    Step 1: On the day before the experiment is to be conducted, ask students to bring to class substances such as vinegar, ammonia, lemon juice, eyewash (boric acid), drain cleaner, salt, sugar, and various brands of shampoo. (Advise students to handle drain cleaner or similar substances with caution.)

    Step 2. Begin by boiling red cabbage in distilled water to obtain a dark, concentrated liquid that will substitute for litmus paper.

    Step 3. The substances listed in step 1 should be poured in equal amounts into glass dishes or test tubes. (A fixed amount of distilled water should be added to the dry substances and the shampoos to create similar consistencies.)

    Step 4. Students should add the same number of cabbage solution drops to each of the different substances. The number of drops added will depend on the concentration of the cabbage solution. Two or three drops may be sufficient, but more may be necessary to cause a change. The resulting color changes in liquids will range from bright red (acidic substances) to purple (neutral substances); brownish green to bright green and yellow (alkaline substances).

    Step 5. An optional step would be to compare the color of the resulting liquids with a graded series of buffer (stabilized) solutions which can be purchased fairly inexpensively from chemical supply companies.

11. Celebrate National Chemistry Day on November 6. The American Chemical Society has 182 local sections, many of which sponsor special programs, exhibits, and other events for students. ACS local sections often distribute videotapes and other educational materials to schools.

[1]Experiment provided by Susan McGrath, Huron High School, Ann Arbor, MI.

Supplementary Materials for Students

Outstanding Women in Science: Chemistry

Occupation: Director of Corporate Research & Analytical Sciences at the Standard Oil Company, Cleveland, Ohio.

Education: Ph.D., Chemistry, Ohio University, 1950.

Awards and honors: Coblentz Society, Williams-Wright Award, 1980; Society for Applied Spectroscopy, Distinguished Service Award, 1983; American Chemical Society, Garvan Medal, 1986.

Professional service: President, Society for Applied Spectroscopy; Editorial Board Member, *Applied Spectroscopy Reviews*; Founding Member, Federation of Analytical Chemistry and Spectroscopy Societies; Chairman, Board of Assessment, National Measurement Laboratories, National Bureau of Standards.

Jeanette G. Grasselli

When Dr. Grasselli first expressed an interest in chemistry, her parents were not certain she would be able to "develop a career in that field." A supportive high school chemistry teacher encouraged her to pursue her interests and helped her obtain a scholarship to Ohio University, where she received a Ph.D. in chemistry in 1950.

Dr. Grasselli began her 37-year career at Standard Oil of Ohio at a time when many employers were reluctant to hire women because they were perceived as likely to retire after only a few years to raise families. She now holds the highest position of any woman at Standard Oil and directs a research staff of 300.

Dr. Grasselli is a recognized authority on the chemical applications of spectroscopy, a method of analysis that enables chemists and other scientists to study the chemical compositions of substances by analyzing their spectra (the amount and quality of light emitted). She pioneered the use of infrared spectroscopy in the petroleum industry, applying it to the development of new petroleum products and plastics. She was one of the first scientists to use computers to interpret infrared spectra.

Dr. Grasselli believes young women entering chemistry today will find increased opportunities and more supportive environments in which to work.

But she also advises that chemistry requires dedication, a commitment to studying, and often the willingness to work more than eight-hour days. "I believe the real key to success is demanding excellence from yourself and others," she says. "This means applying every skill you have in the most dedicated way."

Young women who wish to succeed in the sciences, advises Dr. Grasselli, "must enter with their eyes open, be willing to work hard, and have confidence that they can make it."

Chemistry Interest Assessment

The following questions reflect some of the common interests of chemistry professionals. If you answer yes to many of these questions, you might want to consider a career in chemistry.

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1. Have you ever owned a chemistry set or taken chemistry? Do you find it interesting to spend time finding out how chemicals react under different conditions?

   Yes _____ No _____

2. Do you like mathematics?

   Yes _____ No _____

   Science?

   Yes _____ No _____

3. Do you enjoy keeping records? Have you ever kept a diary or journal?

   Yes _____ No _____

4. Do you like memory games?

   Yes _____ No _____

5. Do you ask "why?" often?

   Yes _____ No _____

6. Have you ever collected objects such as rocks or shells and tried to identify and categorize them?

   Yes _____ No _____

7. Do you like to work with your hands?

   Yes _____ No _____

8. When a problem is difficult to solve, do you usually stick with it until you've found a solution?

   Yes _____ No _____

9. Do you like jobs that involve sorting? For example, would you enjoy separating a group of coins or stamps into different categories?

   Yes _____ No _____

10. Do you sometimes think of new ideas that might never have occurred to anyone else?

    Yes _____ No _____

11. Do you like team sports?

    Yes _____ No _____

12. Do you ever try to predict the weather?

    Yes _____ No _____

13. Do you ever wonder how a microwave oven, stereo, television, or radio work?

    Yes _____ No _____

Career Options in Chemistry

A degree in chemistry can lead to a vast array of career options. Listed below are some common areas of specialization for chemists.

Analytical chemists are concerned with the structure, composition, and nature of substances. They often develop new techniques for analyzing substances. Analytical chemists frequently work to identify specific chemicals in an environment. For example, they might identify the presence of specific airborne pollutants and determine their sources in an effort to reduce air pollution.

Biochemists combine expertise in biology and chemistry to study the complex chemical combinations and reactions involved in metabolism, reproduction, growth, and heredity.

Inorganic chemists study the nature and structure of all compounds that are not hydrocarbons or their derivatives. They often research and work to develop electronic components such as semiconductors.[2]

Organic chemists study the nature and structure of carbon compounds. They frequently work to develop commercial products such as drugs, plastics, and fertilizers.

Physical chemists are concerned with the physical characteristics of atoms and molecules and with the nature of chemical reactions.

General Career Areas

Applied chemistry—A chemist might work in forensics, environmental control, customs labs, occupational safety, health administration, or standards control.

Industry—Industrial chemists are usually involved in the development or improvement of products. Some work in marketing or corporate management.

Research—Research chemists ask questions about the substances that make up the environment. They work in a variety of settings, developing new materials, studying compounds, improving products, and controlling quality in all types of manufacturing operations. Chemistry research can be highly specific to a particular problem or product, or more general, depending upon the work setting.

Teaching—Many chemists teach chemistry and related sciences at the secondary and postsecondary levels. Chemists in universities usually combine teaching with research.

Other options—Museums, insurance companies, and banks often employ chemists. Chemists can also combine their degrees with other kinds of advanced training or research to build careers in law, engineering, and other fields.

Preparing for a Career in Chemistry

Secondary Education

Mathematics—Suggested courses: algebra, geometry, trigonometry, calculus, statistics.

Sciences—Students should take as many chemistry courses as possible. Physics courses are also strongly recommended. Other suggestions include biology, botany, physiology, and zoology.

English and communications—Courses in these curriculum areas help students develop writing, speaking, and other skills that enable them to communicate effectively.

Modern foreign languages—Students should select a language sequence, preferably in French, German, Russian, or Spanish. Language proficiency is necessary for chemists, who often participate in international gatherings and follow research advances reported in foreign journals.

Additional course work—*Computer science*: Computer literacy and experience in programming will be advantageous as computers become more and more integral in scientific research. *Social sciences*: Familiarity with fields such as anthropology, psychology, and sociology is important for scientists concerned with human life and health. *Typing*: Most chemists must be proficient with computer keyboards. *Electronics* and *shop* courses: Many chemists must build and maintain the special equipment they use in their research.

Postsecondary Education

The rapid advancement of a variety of technologies is certain to influence the way future chemists are trained. Current trends suggest that future college chemistry curriculums will be more

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[2]Semiconductors are materials that conduct electricity, such as germanium and silicon. They are frequently used in electronic devices and solar batteries.

interdisciplinary in an effort to prepare students for the new multi-disciplinary high-technology research. Chemistry graduates with expertise in the biological and materials sciences will be in particularly high demand (ACS 1987, 65:43).

Bachelor of Science (B.S.)—During a four-year undergraduate program in chemistry, a student will become familiar with the different branches of chemistry and will also study mathematics, physics, foreign language, and selected subjects in the humanities and social sciences.

During their junior and senior years, chemistry students typically concentrate on specialized courses in biochemistry, physical chemistry, organic chemistry, and inorganic chemistry.

Student research is an important part of undergraduate study in chemistry. Through research, students learn to apply the principles of chemistry and experience the work that chemists actually perform. Students should take advantage of opportunities to conduct or participate in research as early as possible.

A bachelor's degree in chemistry is usually sufficient for entry-level positions. Many graduates enter sales, marketing, technical writing, health professions, and engineering.

Combined degree programs: chemistry and engineering—In addition to a B.S. degree in chemistry, some universities offer a combination B.S. and chemical engineering degree. The joint degree usually requires five years to complete.

Master of Science (M.S.)—Students can choose from a wide range of graduate programs in chemistry. Graduate work can be undertaken in any of the various specializations.

Chemists with master's degrees can usually teach in two-year colleges or work in private industry as technicians and managers.

A Ph.D. is usually required for basic research, four-year college faculty positions, and administrative positions such as directors, senior scientists, vice presidents, and presidents.

Other fields—Students with undergraduate degrees in chemistry may choose to undertake graduate work in related areas such as environmental science, biological sciences, toxicology, pharmacy, astrophysics, medicine, or public health.

A background in chemistry can also be combined with graduate study in unrelated fields. For example, a student might combine a B.S. in chemistry with a graduate degree in law in order to specialize in environmental or patent law.

Outlook and Salaries

Unless otherwise specified, the following trends and statistics were compiled from publications of the American Chemical Society.

- Employment of chemists is expected to grow at a rate of 4–10 percent through the mid-1990s, more slowly than the average for all occupations, according to the U.S. Bureau of Labor Statistics (1986). The American Chemical Society (1986, 64:26) attributes a significant reduction in growth to cutbacks and budget-tightening measures in the U.S. chemical industry.
- The slowdown in growth has not had a major effect on the overall economic well-being of chemists. Salaries, especially for chemists with Ph.D.s, are continuing to increase (ACS 1986, 64:26).
- Demand for chemists was up slightly in the U.S. chemical industry during the first part of 1987, reversing a declining trend that persisted from 1984–1986. In March 1987 only 1.1 percent of chemists were unemployed, representing the lowest number of unemployed since 1981 (ACS 1987, 65:43).
- Most jobs for chemists will be located in private industry, primarily in product development. Advances in high technology fields such as computers, composites, superconductors, biosensors, drug design, and biotechnology are expected to increase the demand for research chemists with multidisciplinary training and expertise (ACS 1987, 65:43).
- Organic chemists and biochemists were in highest demand at the September 1987 ACS National Employment Clearing House (ACS 1987, 65:43).
- There are a growing number of vacancies in academic chemistry departments in colleges and universities across the U.S. A study conducted by the National Science Foundation concluded that faculty positions are increasingly difficult to fill because industry salaries are usually more attractive. Difficulty in securing funding to perform research is another possible factor in the decline of academic chemists (ACS 1987, 65:43).

- The following chart, compiled from a National Science Foundation report (1986) on women and minorities in science, indicates a 3 percent increase in the number of employed women chemists between 1976 and 1984.

Number of Employed Chemists by Sex: 1976 and 1984

Total in 1976	Men	Women
132,800	119,100	13,700
Total in 1984	**Men**	**Women**
168,600	146,300	22,300

- While women comprise an increasingly larger portion of all chemists, the field is still dominated by white males. In 1985, more than three-fourths of all American Chemical Society members were male and white (64:17).
- According to a College Placement Council interim salary survey (March 1987), recent college graduates with B.S. degrees in chemistry can expect to make an average beginning salary of $26,700. Recent graduates with Ph.D. degrees can expect to make $33,200.
- Salaries for chemists are attractive, especially in private industry. In 1987 the highest average salaries ($42,300) were offered to chemists with B.S. degrees in the petroleum and plastics industries. The highest average salaries for chemists with Ph.D.s were offered in the following industries (in descending order): petroleum and natural gas, soaps and detergents, basic chemicals, pharmaceuticals, and electronics (ACS 1987, 65:43).
- Chemists earn more or less depending on their work settings. In 1987, a chemist with a Ph.D. earned a mean salary of $55,700 in industry, $50,200 in government agencies, and $41,300 in universities and colleges (ACS 1987, 65:43).
- Women are less likely to hold management positions and more likely to specialize in lower-paying areas (ACS 1986, 64:17).
- While women chemists entering the job market in the late 1970s and early 1980s tended to earn more than comparable men chemists, recent surveys show that inexperienced men chemists at all degree levels now earn more than comparable women chemists (ACS 1987, 65:43).
- A study of median annual salaries conducted by the American Chemical Society in 1987 showed that women chemists with B.S. degrees earn 3 percent less than comparable men. Women chemists with M.S. degrees earn 2 percent less, and those with Ph.D. degrees earn 5 percent less than comparable men. The salary gap rises according to years of experience, due in part to the fact that women are less likely to be managers than men (ACS 1987, 65:43).

For More Information

Associations and organizations

American Chemical Society, Department of Educational Activities, 1155 16th St. N.W., Washington, DC 20036; 202/872-4600.

American Institute of Chemical Engineers, 345 E. 47th St., New York, NY 10017; 212/705-7660.

Chemical Institute of Canada, 151 Slater St., Ste. 906 Ottawa, ON K1P 5H3; 613/233-5623.

Council for Chemical Research, P.O. Box AJ, Allentown, PA 18106; 215/395-4550.

Women Chemists' Committee, American Chemical Society, 1156 16th St. N.W., Washington, DC 20036; 202/872-4456.

Chemical companies

Colgate-Palmolive Company, Technical Information Center, 909 River Rd., Piscataway, NJ 08854; 201/878-7574.

Eli Lilly and Co., Scientific Library, Lilly Corporate Center, Indianapolis, IN 46285; 317-261-4030.

Directories of professional associations

Encyclopedia of Associations. Denise Akey, editor. Detroit: Gale Research Company (updated biennially).

National Trade and Professional Associations of the United States and Canada and Labor

Unions. Washington, DC: Columbia Books, Inc.

Other resources

Younger Chemists: In Transition. A film available from the American Chemical Society, Department of Educational Activities, 1155 16th St. N.W., Washington, DC 20036; 202/872-4600.

References

American Chemical Society. 1987. 1988 Employment Outlook. *Chemical and Engineering News* 65:43.

_____. 1986. Survey Data Probe Status of Chemists. *Chemical and Engineering News* 64:17.

_____. 1986. Unemployment Slightly Higher for Chemists in the Past Year. *Chemical and Engineering News* 64:26.

_____. 1985. *Chemical and Engineering News* 63:30–25.

National Science Foundation. January 1986. *Women and Minorities in Science and Engineering*. Washington, DC.

U.S. Bureau of Labor Statistics 1986. *Occupational Outlook Handbook*. Washington, DC: Government Printing Offices. 1986-87 edition. Bulletin 2250.

Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

Chemistry graduate students prepare a Time of Flight (TOF) laser ionization mass spectrometer to analyze the masses of chemical compounds.

Program 3
Computer Science

Program Summary

The narrator explains that computers have become indispensable tools for processing and managing information, finding solutions to problems, making predictions, and generating designs in many fields. Computers have created an explosion of new career opportunities, and large numbers of women are taking advantage of them.

The program features computer scientists working in a variety of settings and illustrates the diversity of careers available to those with education and training in computer science.

Some computer scientists program computers to perform specific tasks, some analyze complex data, some perform research to advance the development of artificial intelligence.[1] Others use computers to make models of natural systems such as the upper atmosphere.

The program focuses on seven women who have chosen computer science as a career.

In order of appearance

- **Bonnie Hausman**, B.S., is a scientific programmer with the National Oceanic and Atmospheric Administration.
- **Linda Benson**, B.S., is a systems analyst with the Wells Fargo Bank.
- **Sharon Schmidt**, a data processing coordinator for the NCR Corporation, specializes in sales of computer systems to banks. She holds a bachelor's degree in mathematics and a master's degree in business administration.
- **Dianne Lyons** owns and manages DataSkills, a school for home-computer education. She holds a master's degree in mathematics.
- **Pat Cole**, a software manager and computer graphics expert, works for a special programs group at Atari, Inc. She holds a master's degree in applied science and has contributed to film projects such as *Star Trek II: The Wrath of Khan* and *Superman III*.
- **Elaine Kant**, Ph.D., teaches and conducts research concerning computers and artificial intelligence at Carnegie Mellon University.
- **Ellen Scott** is a senior majoring in computer science at Michigan State University.

The women featured in the program often mention the satisfaction they derive from solving both big and little problems in the course of their work with computers. Many also mention the challenging and creative aspects of their careers.

The program explains that many college graduates with bachelor's degrees begin their careers as computer programmers and are promoted to systems analyst positions. Some computer scientists work for large firms and eventually take positions in management or sales. Others conduct research in universities, businesses, or government institutions.

Most successful computer scientists possess intelligence, creativity, strong logical thinking skills, and good preparation in science and mathematics.

The program reviews recommendations for high school and college preparation for computer science careers. High school students interested in computer science should begin with courses in science and should plan to take at least three years of mathematics. High school computer science courses are also strongly recommended.

Did You Know?

- In 1985, 36.9 percent of all bachelor's degrees in computer science were awarded to women, as compared to 18.9 percent in 1975 (National Science Foundation 1988).
- According to a 1986 survey of approximately 1,700 data processing companies, 18 percent of all programmers and systems analysts em-

[1] Artificial intelligence is a branch of computer science devoted to researching ways to design "intelligent" computers with the capacity to perform tasks such as reasoning, adapting to new situations, and learning new skills.

ployed by the companies were women, as compared to 13 percent in 1978. The median age for women programmers and systems analysts was 36, as compared to 39 for men, suggesting that the majority of women have entered the field more recently (*Datamation* 1987, 33:6).

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Computer Science Interest Assessment on page 27, and then proceed with an introductory discussion.

1. What type of work might a computer scientist perform?
2. What type of education is necessary?
3. Where might a computer scientist work?
4. What kind of person might be a successful computer scientist?

After the Program

Possible answers to the following discussion questions are in parentheses.

1. What are some common job titles of computer scientists? (data processing coordinator, programmer, professor, researcher, software manager, systems analyst)
2. What kind of person might be attracted to a career in computer science? (people who are bright, inquisitive, and creative; people who are able to think logically and who enjoy problem solving; personable, articulate people who are willing to adapt to new situations)
3. What is the main task of a computer scientist? (Information control: computer scientists use computers to organize and manage complex systems of information.)
4. How does the work of a systems analyst differ from that of a programmer? (A systems analyst designs systems that dictate how computers will store and retrieve information. A programmer translates the analyst's designs into step-by-step instructions for the computer. In designing an inventory control system, for example, a systems analyst would determine what data should be collected, what hardware[2] should be used, and what software[3] should be used or developed.)
5. What kinds of high school courses would best prepare a student for entry into a college program in computer science? (Courses in science, social studies, English, foreign languages, and communications are strongly recommended.)
6. Why might it be sensible for a college student who had not yet decided on a career goal to major in computer science? (The current computer revolution will affect nearly every field, making computer science a good foundation for many careers.)
7. What kind of work schedule might a computer scientist expect? (Computer scientists usually work regular office hours. Some are called on to attend to computer problems whenever they occur. Others work according to their own schedules.)
8. What kinds of information-processing tasks might computers perform? (Computers can be applied to design tasks such as generating graphics for movie and video game animation. Computer-Aided Design (CAD) is a design method often used by engineers to transform designs into simulated three-dimensional models. In Computer-Aided Manufacturing (CAM), these models can serve as guides to robots and other computer-controlled mechanisms used in manufacturing.)
9. Why is a good mathematics background helpful to a computer scientist? (Mathematics provides training in logical thinking. Mathematical problems are often assigned in programming courses. Computer scientists often work with mathematical data bases and apply mathematics in designing data processing systems.)

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[2] In computer terminology, hardware refers to electronic or mechanical devices, such as monitors, keyboards, hard disks, and printers, used in data processing.

[3] Software refers to detailed instructions or programs written in computer languages, which enable computers to organize and manipulate data in a logical and useful way.

10. Why might computer science be an appealing career choice for women who are planning marriage and children? (Some computer science careers allow flexibility in work schedules. Many computer science careers, although demanding, pay high salaries which enable dual-career couples to afford domestic assistance and child care.)

Supplemental Activities

1. Invite local computer science professionals and students to discuss their training and careers.

2. Encourage high school students to join their school chapter of JETS, INC. (Junior Engineering Technical Society). If the school has no JETS, INC. chapter, help students organize one. The society encourages students to explore engineering and applied science through project work and activities. Chapters operate in high schools, under the guidance of a teacher. Practicing engineers serve as volunteer technical advisers. For more information, contact the United Engineering Center, 345 E. 47th St., New York, NY 10017; 212/705-7690.

3. Organize field trips to places where computer scientists work. (computer hardware or software companies, businesses, universities, hospitals)

4. Take a trip to a local computer store. Students should be prepared to ask informed questions about memory capacity, keyboard design and function, number and types of applications, hardware components, display terminal features, computer languages, and interfacing capacities.

5. Have students think of ways in which computers could help them at home with their daily activities.

6. Ask students to figure out how a computer-aided mechanism such as a robot might be designed and programmed.

7. Arrange for students to play chess against a computer.

8. Suggest that students role-play a woman computer scientist and her husband as they decide how the household chores and child-care responsibilities are to be divided and accomplished.

9. Have one student role-play a prospective science major. Another student can role-play a college admissions counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in computer science. Discuss and role-play methods of coping with direct and subtle discouragement.

10. Investigate summer programs that allow students to get a head start in computer science training. Information on such programs might be available from local school boards, nearby universities, or computer science associations.

11. Have students bring to class help-wanted newspaper ads for computer science careers. Discuss the qualifications required, the types of jobs described, and the salary range offered. Have students write to the personnel departments of leading data processing companies to learn more about computer science jobs in business. A list of leading U.S. data processing companies is on page 31.

12. Keep a bulletin board or scrapbook with information on women in computer science careers.

13. Check the library or bookstore for recent articles, magazines, and books on computer topics. Some suggested computer magazines include: *Byte, Computer World, Datamation, Info World, Personal Computing, PC World,* and *Mac World.*

Supplementary Materials for Students

Outstanding Women in Science: Computer Science

Sara A. Bly

Occupation: Member of the Research Staff at Xerox Palo Alto Research Center, Palo Alto, California.

Education: Ph.D., Computer Science, University of California, Davis.

Professional service: Treasurer, 1988-90, and Vice Chair, 1983-84, Association for Computing Machinery (ACM), Special Interest Group on Computer Graphics; Secretary, 1988-90, ACM.

Dr. Bly and her colleagues are researching ways in which technologies such as video can help make computers more efficient and more supportive of people who use them. Her research focuses on improving user interfaces—the part of a computer program users actually see and interact with while working.

She and other members of the System Concepts Laboratory at Xerox PARC have worked on a number of projects linking video and computers. One such project included an experiment designed to explore whether workers in distant offices could see each other, talk, and collaborate effectively on a daily basis. Through a complex network of computers, cameras, and microphones, her group shared ideas, held meetings, and even "ate lunch" with another group of researchers in Portland, Oregon.

As a sophomore, Dr. Bly had decided to major in education until a supportive professor encouraged her to take a degree in mathematics. After graduating in 1968, she pursued her interest in education, completed a master's degree, and taught high school mathematics for several years. "Then I decided it was time to try something different," she says. "Having a math degree meant I had options."

In 1972 she accepted a position at Lawrence Livermore National Laboratory (LLNL), where she worked part time and developed an interest in computer programming. She completed her master's degree and doctorate in computer science while continuing to work at LLNL, where she supervised a team designing a computer graphics simulation system for tactical defense planning.

Dr. Bly cautions young women who have not yet made a career choice: "Don't make a decision now that will narrow your options later. Take all the math and science you need to keep your options open," she advises. "Build your confidence by participating in activities that develop your talents and make you feel good about yourself. Find a role model whom you admire. If someone tries to discourage you, remember: never depend on just one person's perception of the world."

Computer Science Interest Assessment

The following questions reflect some of the common interests of computer science professionals. If you answer yes to many of these questions, you might want to consider a career in computer science.

1. Do you look for logical explanations to questions?

   Yes _____ No _____

2. Do you want to learn more about how computers work?

   Yes _____ No _____

3. Do you enjoy meeting challenges?

   Yes _____ No _____

4. When working on a complicated problem, do you often pay attention to detail in figuring out the solution?

   Yes _____ No _____

5. Would you enjoy working with a team?

   Yes _____ No _____

6. Do you like putting jigsaw puzzles together?

   Yes _____ No _____

7. When a problem is difficult to solve, do you usually stick with it until you've found the answer?

   Yes _____ No _____

8. Are logic games such as bridge and chess appealing to you?

   Yes _____ No _____

9. Before starting a new task, do you like to plan how you're going to accomplish it?

   Yes _____ No _____

10. Do you enjoy using your imagination to create new things?

    Yes _____ No _____

Using a computer to solve a mathematics problem gives these students hands-on experience and helps them see how computers are applied in many different fields.

Career Options in Computer Science

A professional in computer science can choose from a number of career options. The following represent some of the most common computer science careers (Career Associates 1985).

Computer programmers are employed in business, health care, government, universities, and many other settings. Programmers write programs that enable computers to perform complex operations. For example, a programmer might write a program that would enable a large university to retrieve information about its students by name, academic year, grade point, address, and sex.

Programmers are usually divided into two general categories. **Systems programmers** work to prepare computers for the general kinds of functions they will perform in a specific work setting such as a bank or a laboratory. They work with low-level computer languages called assembly languages. **Applications programmers** prepare computers to perform specific tasks for business or scientific applications using high-level computer languages such as Cobol or Fortran. In general, systems programming is considered to be more technical than applications programming, and salaries are generally higher.

A bachelor's degree is usually required for programming positions, and many employers require a graduate degree. Some programmers are trained in business, but have taken special courses to supplement their skills.

Employers in science and engineering prefer programmers with degrees and experience in computer or information science, mathematics, engineering, or physical sciences. Business employers prefer experience in accounting, inventory control, and other business skills (U.S. Bureau of Labor Statistics 1986).

Systems analysts design complex systems of information management. For example, a systems analyst working to design an inventory control system for a large retail business would need to decide what types of data should be collected, processed, and reported. Working closely with the business managers to determine their specific needs, the systems analyst would decide what type of computer system would best address these needs and then work with computer programmers to develop and install the computer hardware and software.

Most systems analysts work in manufacturing, government agencies, banks, insurance companies, and data processing firms (U.S. Bureau of Labor Statistics 1986).

Most analysts have at least a bachelor's degree, and many employers require graduate degrees. Most analysts have worked as programmers, engineers, or managers before advancing to their present jobs.

Data telecommunications specialists work with networks of computers, designing ways to transmit data from computer to computer through a variety of telecommunications technologies. They often install and maintain special communications hardware and software.

Technical support representatives, also called **systems engineers**, are usually experts in a particular line or brand of computers. They are often employed by computer companies and manufacturers to assist customers with problems and questions.

Electronic data processing auditors, usually called **EDP auditors**, often work in the finance or auditing departments of large corporations. They monitor, evaluate, and generally oversee large computer operations. Some EDP auditors work for professional accounting firms.

Documentation specialists translate the technical computer terminology used by programmers, analysts, and software developers into a simpler language for computer users. They write manuals describing the designs and functions of software and hardware, so that nonexpert computer users can use programs and equipment more quickly and efficiently.

General Career Areas

Business management and sales—Computer science graduates often work in business. They might work for computer corporations that develop or manufacture computer software and hardware or in any business in which computers play an integral role.

Teaching and research—Some graduates choose academic environments. Computer scientists in universities generally combine teaching and research.

Research is also carried out in hospitals and clinics. As biotechnology advances, health care providers rely increasingly on computers and computer specialists.

Teaching opportunities are also available in corporations and in the armed services. Corporations, industry, and government institutions also employ computer scientists to conduct applied research.

Consulting—Consultants work in business, education, government, health care, and industry, wherever people use computers extensively and need advice or training.

Future options—Computer professionals are expected to be in demand in many areas as more complex computer applications develop in many fields. Future computer scientists will find job opportunities in

- ***education***, as educators incorporate more computers into schools
- ***medicine***, as doctors utilize computer-aided diagnostic programs and as hospitals, clinics, and laboratories rely more on computers to store and retrieve information
- ***fitness and recreation***, as fitness specialists increasingly apply computer technology to the task of monitoring the human body during exercise and sports performance
- ***financial institutions and retail outlets***, as they advance in their development of computerized services for customers
- ***engineering***, as researchers develop more and more complex robotics systems for use in industry and other fields. Computer and software engineering are two rapidly growing fields with job opportunities for those trained in engineering and computer science. Software engineers are expected to be in particularly high demand through the mid-1990s (Revell 1985).

Preparing for a Career in Computer Science

Secondary Education

Mathematics—Because formal logic is important in computer science, students should acquire a strong background in mathematics. Suggested courses: algebra, geometry, trigonometry, calculus, statistics.

Sciences —High school science courses help students develop the background they need to combine their knowledge of physical or medical science with computer science in a future career. Recommended courses: chemistry, physics, biology, physiology, and zoology.

English and communications—Courses in these curriculum areas help students develop writing, speaking, and other skills that enable them to communicate effectively.

Modern foreign languages—Students should select a language sequence, preferably in French, German, Russian, or Spanish. Language proficiency is necessary for computer scientists, who often participate in international gatherings and follow research advances reported in foreign journals.

Additional course work—*Social sciences*: Familiarity with the fields of anthropology, psychology, and sociology is important for scientists concerned with human life and society. *Philosophy*: Because logic and symbolic logic are integral to computer science and mathematics, philosophy is an important discipline for computer scientists. Introductory course work in philosophy will help prepare students to take higher level philosophy courses required in college.

Postsecondary Education

Bachelor of Science (B.S.)—Undergraduates majoring in computer science at most colleges and universities will be required to take courses in mathematics, natural and social sciences, logic and symbolic logic, statistics, humanities, and communications. Courses within the undergraduate major might include artificial intelligence, computer graphics, computer languages, data base systems, digital computer engineering, operating systems, software, and others.

Combined degrees—Students interested in computers can choose to follow a program which combines computer science with another area of study. A double major in computer science and mathematics or statistics is considered highly useful in business, science, and many other fields.

Computer Information Systems (CIS)—The computer information systems degree is usually offered by business schools. CIS focuses on commercial applications of data processing systems.

Master of Science (M.S.) and Doctor of Philosophy (Ph.D.)—Students who wish to pursue graduate study in computer science have several options. Programs in computer engineering include advanced study in computer hardware and applications. Operations research, which deals with problems such as optimizing the efficiency of a complex computer informa-

tion network, is another option for graduate study.

A graduate degree—usually a Ph.D.—is necessary for college teaching and research and for many nonacademic computer science positions.

Outlook and Salaries

- While the U.S. Bureau of Labor Statistics projects that employment of programmers and systems analysts will grow more than 30 percent (much faster than the average for all occupations) through the mid-1990s, the College Placement Council (July 1986) reported a slowdown in the number of offers made to computer science majors between 1985 and 1986. Changing economic trends and rapid advances in computer technology may create fluctuations in employment opportunities for computer scientists.

- Hiring slowdowns were also evident in a 1987 review of 100 leading U.S. data processing-oriented companies. The survey, conducted by *Datamation* magazine (1987, 33:12), revealed that by the end of 1986 the leading companies employed a total of 6.63 million people, about 13,000 less than in 1985.

- The U.S. Bureau of Labor Statistics *Occupational Outlook Handbook* (1986-87) projects the following trends in computer science employment.

  Employment opportunities will be most numerous for college graduates who are familiar with several programming languages. Knowledge of newer languages that apply to computer networks and data base management are most in demand.

  Field experience through work-study or internship programs in applied fields such as accounting, management, engineering, or science will help college graduates secure entry-level jobs.

  Graduates of two-year programs in data processing and those with less training and work experience will find more competition in the job market.

- According to a College Placement Council interim salary survey (March 1987), the average beginning monthly salary offered to college graduates with bachelor's degrees in computer science was $2,162, an average annual salary of $25,900. Graduates with master's degrees were offered an average beginning monthly salary of $2,767, an average annual salary of $33,200.

- Average starting salaries for computer science graduates increased 15 percent during the mid-1980s and are expected to continue to increase sharply according to research conducted by the Commission on Professionals in Science and Technology. The commission predicts shortages of computer scientists in the 1990s due to declining undergraduate enrollment in computer courses nationwide.

- A 1987 survey of 595 data processing firms conducted by *Infosystems* magazine revealed that the highest salaries in computer science fields are earned by presidents and vice presidents of large data processing-oriented companies. Many earn salaries of $100,000 or more. The second-highest salaries are earned by data telecommunications specialists and managers. The survey also indicates that salaries of data telecommunications specialists are continuing to rise, indicating high demand.

- Computer scientists working in large data processing companies can earn up to $5,000 more annually than those working for smaller companies. Those working in utilities and government institutions also rank well on the salary scale. Computer scientists working in colleges and universities are generally paid less than most in the field (*Datamation* 1987, 33:6).

For More Information

Associations and organizations

American Federation of Information Processing Societies, 1899 Preston White Dr., Reston, VA 22091; 516/757-5664.

American Society for Information Science, 1010 16th St. N.W., 2nd Floor, Washington, DC 20036; 202/659-3644.

Association for Computing Machinery, 11 W. 42nd St., 3rd Floor, New York, NY 10036; 212/869-7440.

Association for Women in Computing, 407 Hillmoor Dr., Silver Spring, MD 20901; contact: Nancy Mae Bonney.

Association for Systems Management, 24587 Bagley Rd., Cleveland, OH 44138; 216/243-6900.

Computer Society—IEEE (International of Electrical and Electronics Engineers), 1109 Spring St., Ste. 300, Silver Spring, MD 20910.

Data Processing Management Association, 505 Busse Hwy., Park Ridge, Ill 60068; 312/825-8124.

Women in Information Processing, 1000 Connecticut Ave. N.W., Ste. 9, Washington, DC 20036; 202/328-6161.

U.S. data processing companies

The following companies were the leading ten U.S. data processing companies in 1986 (*Datamation* 1987, 33:12).

1. International Business Machines (IBM), Old Orchard Road, Armonk, NY 10504; 914/765-1900.
2. Unisys Corp., One Unisys Place, Detroit, MI 48232; 313/972-7000.
3. Digital Equipment, 146 Main St., Maynard, MA 01754; 617/897-5111.
4. Hewlett-Packard Co., 3000 Hanover St., Palo Alto, CA 94304; 415/857-1501.
5. NCR Corp., 1700 S. Patterson Blvd., Dayton OH 45479; 513/445-5000.
6. Control Data Corp., 8100 34th Ave. S., Bloomington, MN 55420; 612/853-8100.
7. Wang Laboratories Inc., 1 Industrial Ave., Lowell, MA 01851; 617/459-5000.
8. Xerox, P.O. Box 1600, Stamford, CT 06904; 203/329-8700.
9. AT&T Co., 550 Madison Ave., New York, NY 10022; 212/605-5500.
10. Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014; 408/996-1010.

References

Career Associates. 1985. *Career Choices for Students of Computer Science.* New York: Walker and Company.

College Placement Council, March 1987. *Salary Survey.* Formal Report No.2.

_____. July 1986. *CPC Salary Survey: A Study of 1985-86 Beginning Offers.* Formal Report No. 3.

Datamation. 1987, 33:12. The *Datamation* 100.

_____. 1987, 33:6–91. What You Should Know About Programmers.

Infosystems. 1987, 34:6. 29th Annual DP Salary Survey Report.

National Science Foundation. 1988. Division of Science Resources Studies. *S/E Degrees series.*

Revell, Diane B. 1985. Software Engineering. *U.S. Woman Engineer.* May/June.

U.S. Bureau of Labor Statistics 1986. *Occupational Outlook Handbook.* Washington, DC: Government Printing Offices. 1986-87 edition. Bulletin 2250.

Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

Program 4
Dentistry

Program Summary

Although women in the U.S. have been entering the dental profession for over a century, women dentists were rare until the 1970s when the number of women enrolled in dental schools increased dramatically. Today, the number of women entering dental school continues to increase gradually.

The program describes a variety of career options. While most students choose general dentistry, many others choose to specialize in areas such as orthodontics, oral surgery, and pediatric dentistry. Those interested in teaching and research pursue academic dentistry, usually combining their other responsibilities with clinical practice.

The program features four successful women dentists and two students of dentistry.

In order of appearance

- **Sheryl Pomerance**, D.D.S., manages her own general practice in Taylor, Michigan.
- **Judith Davenport**, D.M.D., returned to school after her children were grown to begin her career in dentistry. She now works in a private clinic in Pittsburgh.
- **Carol Drinkard**, D.D.S., M.S., specializes in pedodontics. She combines teaching, research, and clinical practice at The University of North Carolina at Chapel Hill School of Dentistry.
- **Gloria Kerry**, D.D.S., M.S., is a periodontist who divides her time between teaching at The University of Michigan School of Dentistry and managing a large private practice. Her daughters, **Julie** and **Karen**, are dental students. They discuss various aspects of growing up in a family with a working professional mother as well as their own decisions to pursue careers in dentistry.

Although the training required for a degree in dentistry is demanding and expensive, the women featured in the program speak frequently of the rewards. They mention the satisfaction of working to improve the health and lives of their patients, and the independence, good salary, and flexibility in work schedules that accompany a career in dentistry.

The program reviews recommended course work for high school and college preparation for dental school. High school students should develop a strong background in mathematics and science and should continue this preparation in college. Along with good academic preparation, students should pursue activities that develop manual dexterity such as playing a musical instrument.

Dental schools require at least two years of undergraduate course work for admission. Most students admitted to dental schools have completed a full four years of college. Four years of study, sometimes including summer sessions, are required for graduation from dental school. Good grades, dedication, and persistence are all important for success. While the dentists and students interviewed in the program agree that dental school is challenging, they also agree that the rewards of practicing dentistry are worth the investment of time, money, and effort.

Did You Know?

- In 1987 women represented approximately 27 percent of all graduates of U.S. dental schools, as compared to 2 percent in 1974–75 (American Dental Association Division of Educational Measurements 1986–87; Manpower Data Resource Service 1986).
- In 1985 women comprised 6.5 percent of all U.S. dentists, as compared to 3 percent in 1982 (U.S. Bureau of Labor Statistics, January 1986; American Dental Association Bureau of Economic and Behavioral Research 1984–85).

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Dentistry Interest Assessment on page 35 and then proceed with an introductory discussion.

1. What kind of individual might be a successful dentist?

2. What type of education is required?

3. Which aspects of dentistry appeal to you?

4. Where else might a dentist work other than in a private practice?

5. What aspects of dentistry might enable a woman to balance a family and a career?

After the Program

Possible answers to the following discussion questions are in parentheses.

1. What are some of the factors that you find attractive about dentistry? What would motivate you to enter the dental profession? (flexible work schedule, variety of career options and environments, opportunity to help people, independence)

2. What are some of the aspects of dentistry which facilitate the combination of career with marriage or child raising? (flexible, personalized work schedules; job security, financial security)

3. What types of courses would best prepare a student who plans to attend dental school? (a solid background in mathematics, science, and English; college courses in chemistry, biological sciences, comparative anatomy, and related sciences.)

4. What characteristics should a dentist possess? (intelligence, interest in science and the health professions, persistence and dedication, ability to enjoy working with others, good manual dexterity and hand-eye coordination)

5. What type of dentistry would best fit the lifestyle you would like to live? (Work schedules vary greatly depending on the work environment and specialty. Private practice usually enables a dentist to have more flexibility in work hours. Salaries vary greatly depending on specialization and work setting.)

6. Dental education requires a considerable investment. What are some of the ways in which a dental education might be financed? (Dental schools offer a variety of financial assistance, including government student loans. Banks and other financial institutions also offer student loans. Part-time jobs during dental school are not recommended.)

Supplemental Activities

1. Invite local dentists who represent a variety of career options such as general practitioner, specialist, teacher, and researcher to speak to your class or group.

2. Invite students who are currently pursuing a career in dentistry to speak about their experiences in dental school.

3. Ask students to make a "wish list" of goals and hopes they hold for their lives. Conduct a discussion in which the students compare their lists with their career goals. For example, female high school students often say they plan to work for a while and then stay home to raise a family. Changing economic trends have made this arrangement unrealistic for most women. Encourage students to examine realistically whether their ideal lifestyle can be achieved.

4. Assign individual research papers on various topics such as new trends in dental practice, specializations within the field, an in-depth look at dental school, and other topics. Have students present their findings to the class or group.

5. Schedule a field trip to a local dental school, research laboratory, or dental office.

6. Have students learn proper dental hygiene techniques, and (if appropriate) teach them to a younger sibling.

7. Have students interview professionals in the dental field and report their findings to the class or group.

8. Keep a file or bulletin board on women in dentistry. Share this information with other classes, counselors, librarians, and teachers, and encourage them to be aware of these and other nontraditional career opportunities for women.

9. Have one student role-play a prospective dentistry major. Another student can role-play a college admissions counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in dentistry. Discuss and role-play methods of coping with direct and subtle discouragement.

Supplementary Materials for Students

Outstanding Women in Science: Dentistry

Linda C. Niessen

Occupation: Director of the Geriatric Dental Program at the Veterans Administration Medical Center, Perry Point, Maryland.

Education: D.M.D., School of Dental Medicine, Harvard University, 1977; M.P.H., School of Public Health, Harvard University, 1977.

Awards and honors: Choctaw Tribe, Outstanding Service to the Choctaw Nation of Oklahoma, 1980; American Dental Association, Geriatric Dental Award, 1986.

Professional service: President Elect, American Association of Public Health Dentistry; President, American Association of Women Dentists, 1984; Fellow, American College of Dentistry; Diplomate, American Board of Dental Health.

Dr. Linda Niessen is a public health dentist who specializes in the field of geriatric dentistry. She provides dental care to patients and conducts research at the Veterans Administration Medical Center in Perry Point, Maryland. Her research concerns the frequency and types of oral diseases that afflict veterans; she examines how frequently tooth decay and periodontal disease occur in these patients. Dr. Niessen also teaches gerontology and geriatric dentistry at the University of Maryland Dental School.

After graduating from dental school, she accepted a position with the U.S. Public Health Service's Division of Indian Health. While serving as Chief of the Dental Service at the Indian Hospital in Talihina, Oklahoma, her concern over the high caries (decay) rates among local children prompted her to organize a campaign to fluoridate the Talihina water supply. "It's rewarding to know that future generations of children will not have the pain of dental decay that their brothers and sisters suffered," she says.

In 1982 she entered the Veterans Administration Dentist Geriatric Fellowship Program at the Boston Outpatient Clinic to study aging and its relation to oral health. She accepted her current position in 1984.

Reflecting on the challenges of a career in dentistry, Dr. Niessen comments: "It is hard work, but the work was always something I liked doing, so the long hours never felt hard. I have a very supportive husband, and our child-care problems have always been jointly resolved. My recommendation to a young woman considering dentistry is to develop and maintain a good sense of humor. Take your work seriously, but never yourself. If you are inclined to marry, marry a supportive, understanding man who isn't threatened by your success and who can enjoy it as much as you will."

Dentistry Interest Assessment

The following questions reflect some of the common interests of dentists. If you answer yes to many of these questions, you might want to consider a career in dentistry.

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1. I find some of these occupations attractive: surgeon, nurse, paramedic, scientific researcher.

   Yes _____ No _____

2. I enjoy some of the following activities or other activities that require working with my hands: drawing, needlework, sculpture, making models, playing a musical instrument.

   Yes _____ No _____

3. I would like to find a career in which my hours would be regular.

   Yes _____ No _____

4. I would enjoy working for myself.

   Yes _____ No _____

5. When I have a job to do, I usually plan it in detail and then follow through by working in a steady manner.

   Yes _____ No _____

6. In school I enjoy courses like botany, chemistry, geology, geometry, mechanical drawing, physics, and zoology.

   Yes _____ No _____

7. I have considered pursuing a career after marriage.

   Yes _____ No _____

8. I believe security and permanence are important factors in a job.

   Yes _____ No _____

9. I would like to find a job in which I can apply my knowledge and skills.

   Yes _____ No _____

10. I enjoy the freedom of working out my own methods of accomplishing a task.

    Yes _____ No _____

Judith Davenport, D.M.D., treats a patient. She decided to become a dentist after her children were grown and now practices in a private clinic in Pittsburgh.

Career Options in Dentistry

General dentistry involves the examination, diagnosis, and treatment of the teeth, jaws, and surrounding soft tissues of the mouth. Many kinds of dental practices are performed in general dentistry such as diagnosing and filling cavities, extracting teeth, performing root canals, and replacing lost teeth with bridges or dentures. General practitioners often emphasize preventive dentistry, encouraging and teaching patients to adopt good dental hygiene and nutrition, which help maintain healthy teeth and gums.

Most dentists practice general dentistry. Approximately 20 percent practice in one of the following eight specialty areas recognized by the American Dental Association (U.S. Bureau of Labor Statistics 1986).

Endodontics is the treatment of diseased tissues of the gums and teeth. Endodontists are specialists in root canal treatment, which involves removing diseased pulp from the tooth and replacing it with special materials, thereby avoiding extraction.

Oral surgery and maxillofacial surgery are surgical specialties for correcting problems such as impacted wisdom teeth and mouth injuries resulting from accidents. In these specialities, techniques are often adapted from plastic surgery to correct cosmetic problems of the jaws and face.

Oral pathology is the diagnosis of mouth diseases. Oral pathologists use microscopes and laboratory tests to determine the presence or absence of tumors and other disorders. Some specialize in forensic dentistry, which involves the application of oral pathology techniques in legal cases.

Orthodontics involves the correction and prevention of irregularities of the position of the teeth. Orthodontists use braces and other devices to correct malocclusion (bad bite) and other types of orthodontic problems.

Pediatric dentistry, also called **pedodontics**, is dentistry for children. Pedodontists use special techniques to manage and treat young patients who sometimes require special attention in preventing and treating dental decay and other problems.

Periodontics is the treatment of the bones, ligaments, and tissue that support and surround the teeth. Periodontal disease is a major cause of tooth loss in adults. Periodontists treat these diseases and help prevent them by educating their patients about proper dental hygiene.

Prosthodontics involves the making of artificial devices such as dentures, crowns, and bridgework to replace missing teeth and to repair damaged teeth.

Public health dentistry involves practicing dentistry and promoting dental health and awareness in a variety of community settings such as public clinics, schools, and hospitals.

Practice Options

After finishing their educations, dentists must choose the practice option that is most convenient and economically feasible for them. Factors such as preferred work schedule and financial capability are important determinants. Most recent dental school graduates begin their careers in a partnership, associateship, or clinic due to the rising cost of solo practice and to increasing competition in the field.

Of approximately 138,000 practicing dentists in 1984, nine out of ten were in private practice. Those who were not were primarily researchers or teachers. Others worked in clinics, hospitals, or in government institutions (U.S. Bureau of Labor Statistics 1986).

Some common private practice options are

- **solo practice**, in which the dentist is the sole owner and operator
- **partnership or group practice**, in which the dentist shares all expenses and profit with other dentists
- **associateship**, in which the dentist is an employee of another dentist-owner and receives a salary or percentage of profit
- **dental clinic**, in which the dentist is an employee and receives a salary or percentage of profit

Some practice options in public health fields include

- hospitals
- public heath clinics
- schools

Other Career Options

Administration and public relations—Some dentists work in administration and management within dental schools, hospitals, and dental associations.

Federal dental services—Dentists practice in all branches of the armed forces.

Teaching and research—Some dentists combine teaching and research with clinical practice in an academic setting such as a dental school. A small number of dentists perform research in private industry.

Schedules

Schedules vary greatly by work environment and speciality. Part-time options are most frequently available in associateships, clinics, and in dental schools. Any privately owned business will afford the greatest flexibility in terms of personal practice style.

Preparing for a Career in Dentistry

Secondary Education

Mathematics—Suggested courses: algebra, geometry, trigonometry, calculus, and statistics.

Sciences—Students are advised to select a strong program in science. Courses in biology, chemistry, physics, physiology, and zoology will be advantageous.

English and communications—Courses in these curriculum areas help students develop writing, speaking, and other skills which enable them to communicate effectively with patients and colleagues.

Additional course work—*Foreign language*: Language proficiency is advantageous for medical and science professionals who often participate in international gatherings and follow research advances reported in foreign journals. *Computer science*: Computer literacy and experience in programming will be necessary as computers become more integral in medicine and science. *Social sciences*: Familiarity with the fields of anthropology, psychology, and sociology is important for professionals concerned with human life and health.

Postsecondary Education

Predental education—Most dental students are graduates of four-year colleges and universities. In 1984, four out of five students admitted to accredited dental schools held bachelor's degrees. Between 1985 and 1987, however, the percentage of students accepted with two years of predental education has increased slightly (American Dental Association Division of Educational Measurements 1986–87).

Prerequisites for dental schools may vary slightly, but most require at least one year of courses in English composition, chemistry (inorganic and organic), biological sciences, and physics.

Most dental schools recommend that students take at least one semester of biochemistry and social sciences such as anthropology and sociology.

Admission to dental school—All dental school applicants must take a national standardized test before applying to dental school. The Dental Admissions Test is used by dental schools to determine the applicant's potential for success in dentistry. Applicants generally take the test before or during the fall semester of their last year of predental course work.

Admission to dental school is based on fulfillment of the predental course work, scholastic achievement, Dental Admissions Test scores, and other personal factors.

Doctor of Dental Surgery (D.D.S.) or Doctor of Dental Medicine (D.M.D.)—Beginning students concentrate on course and laboratory work in basic sciences such as anatomy, biochemistry, microbiology, and physiology. Preclinical technique and introductory courses in clinical sciences are also required.

During their final two years in dental school, students combine their course and laboratory work with clinical practice.

Graduate study—Some dentists continue their dental educations in order to specialize in a particular branch of dentistry. A Master of Science in Dentistry (M.S.D.) requires two or more years of postdoctoral studies. Others take advanced degrees, such as the M.S. and Ph.D., to qualify for teaching and research positions in colleges and universities.

Outlook and Salaries

- Employment in dentistry is expected to grow 20–30 percent through the mid-1990s, faster than the average for all occupations according to the U.S. Bureau of Labor Statistics *Occupational Outlook Handbook* (1986–87 edition). Changes in population size and characteristics, particularly the aging of the "baby boom" generation, are expected to contribute to this growth trend. Increasing public awareness of the importance of regular dental care and an increase in the availability of dental insurance have also contributed to growth in the field of dentistry.

- While the demand for dentists continues to increase, an abundance of general practitioners in private practices will create intense competition in some areas of the country. General practitioners and specialists are expected to remain in demand in high-income urban areas and in small towns (U.S. Bureau of Labor Statistics 1986).

- Salaries vary greatly depending on the type of dentistry practiced and on the work setting. Most beginning dentists work in established practices to gain experience and to save money. Some enter residency training programs in hospitals and dental schools.

- Beginning dentists usually earn considerably less than those who are experienced and well established. Equipment costs, student loan payments, and other start-up costs take up a significant proportion of income for most newly established dentists, but their earnings rise quickly over time (U.S. Bureau of Labor Statistics 1986).

- Specialists in all stages of their careers generally earn considerably more than general practitioners. In 1985 the median income for general practitioners in private practice was $60,000 according to a dental practice survey conducted by the American Dental Association Bureau of Economic and Behavioral Research (1986–87). The median income for specialists in private practice was $98,000.

For More Information

Associations and organizations

American Dental Association, 211 East Chicago Ave., Chicago, IL 60611; 312/440-8900.

American Association of Dental Schools, 1625 Massachusetts Ave. NW, Washington, DC 20036; 202/667-9433.

American Association of Women Dentists, 211 East Chicago Ave., Ste. 948, Chicago, IL 60611; 312/337-1563.

Publications

Russon, James E. *Dentistry: An Inside View.* Salt Lake City, UT, 1979.

Peterson, Shaller. *Preparing to Enter Dental School.* Sterling Swift Publishing Co., Manchaca, TX, 1977.

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American Dental Association: Bureau of Economic and Behavioral Research. 1986–87. *The 1986 Survey of Dental Practice.*

_____. 1984–85. *1984–85 Dental Statistics Handbook.*

American Dental Association: Division of Educational Measurement 1986–87. *Annual Report.* Division of Educational Measurements, Council on Dental Education.

Manpower Data Resource Services. 1986. *Professional Women and Minorities.* Sixth edition. Betty M. Vetter and Eleanor Babco, editors.

U.S. Bureau of Labor Statistics. January 1986. *Employment and Earnings.*

_____. 1986. *Occupational Outlook Handbook.* Washington, DC: Government Printing Offices. 1986-87 edition. Bulletin 2250.

Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

Program 5
Engineering

Program Summary

The program examines various ways in which engineers are essential in modern society. They work behind the scenes in many environments to create, design, and test new products and technologies. Some engineers oversee the design and construction of large buildings and industrial plants, others test the performance of products to determine their durability, efficiency, and safety. Some engineers design and build highly specialized equipment such as computerized cardiology equipment for use in coronary intensive care units.

The narrator explains how the field of engineering has developed from four classical divisions—mechanical, civil, electrical, and chemical—to more than 25 engineering specialties.

The careers of engineers vary enormously according to their specialties, work settings, and project specifications.

The program focuses on seven women who have chosen engineering as a career.

In order of appearance

- **Nena Menlove**, a civil engineer, supervises construction on various projects for Morrison Knudson of Boise, Idaho. She has worked in a variety of environments, including a shale oil refining plant in Salt Lake City.
- **Gail March**, an electrical engineer at Rockwell International, monitors truck functions in the laboratory and in the field.
- **Marta Kindya**, a telecommunications engineer, is a training supervisor for New York Telephone.
- **Janice Jenkins**, an assistant professor in the Department of Electrical and Computer Engineering at the University of Michigan, conducts research in computer applications for cardiology.
- **Christina Lee, Leigh Bryant, and Susan Livingston**, three engineering students, give their views on college academics and social life, and discuss the importance of high school preparation for engineering school.

The engineers featured in the program discuss many aspects of their careers: their various daily responsibilities; the importance of communicating with co-workers; their training and academic experiences; how they balance their personal lives with their professional lives; how they became interested in engineering; and why they enjoy their chosen careers.

These scientists frequently mention the satisfaction they derive from applying their intelligence, resourcefulness, and creativity to complex problems and challenging situations.

The program presents typical college requirements for a degree in engineering, and several of the engineers and engineering students discuss the importance of taking mathematics courses as early as possible in preparation for an engineering career.

Did You Know?

Increasing numbers of women are taking advantage of opportunities in engineering. The National Science Foundation (1984, 3) reported the following statistics.

- Full-time enrollment of women in undergraduate engineering programs increased from 34,000 in 1978 to 62,700 in 1984—an 84 percent increase.
- The number of women engineering graduates has increased sharply in recent years. Engineering degrees represented 10 percent of all science/engineering degrees awarded to women in 1984.
- Engineering was the fastest growing field of doctoral study for women in 1984.

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Engineering Interest Assessment on page 43, and then proceed with an introductory discussion.

1. What types of work might engineers perform?

2. What high school courses help to prepare a student for engineering school?

3. What type of person might be a successful engineer?

After the Program

Possible answers to the following discussion questions are in parentheses.

1. Engineers shape the physical and chemical behavior of materials to meet society's needs. Can you give some examples of ways in which engineers accomplish this feat? (A civil engineer manipulates the properties of building materials such as steel, concrete, and plastic to achieve a required density, weight, tensile strength, and flexibility. Similarly, a chemical engineer works with the properties and reactions of chemicals to produce materials such as synthetic fibers.)

2. How important are mathematics and science in engineering? (Mathematics and science teach "game" rules that govern the practice of engineering. Success in the profession depends upon knowledge of these rules. In other words, mathematics and science teach engineers what nature will and will not allow.)

3. Are good communication skills essential to an engineer? Why? (Yes. An engineer works as part of a team. Communicating well—verbally and in writing—is essential to good project control. Verbal reports and publications are often required of engineers.)

4. The number of women in engineering is increasing. Why? (The success of women who have already entered the field is inspiring others to enter. Changing social patterns have recently enabled more women to step into male-dominated fields. More women are choosing lifelong careers in well-paying professions.)

5. Must women engineers give up traditionally feminine roles and interests in order to succeed? (No. Engineers can also be wives and mothers, and can pursue other personal interests.)

6. Are women engineers apt to face special problems in their profession? (Possibly. Women are still a minority in engineering. A woman might apply undue pressure on herself to combat sexual stereotyping. Another problem women might encounter is the lack of female colleagues. Female engineers facing these and similar difficulties can find support and assistance through a variety of professional women's organizations and societies.)

7. Why is it advisable for high school students who are interested in engineering to take as many mathematics and science courses as possible? (Avoiding mathematics and science in high school might make it difficult to catch up in college, where familiarity with the essential concepts of mathematics and science is essential.)

8. What courses are included in the first two years of the core curriculum of engineering study at a university? (The core curriculum typically includes mathematics and science courses, including calculus, differential equations, linear algebra, physics, chemistry, and computer science. Other requirements include English and communications courses, humanities, and social science courses.)

9. Could an engineering student specializing in a particular area later qualify for work in other areas of engineering? (Yes, in many cases. In the program, Nena Menlove explained that she initially decided to specialize in hydraulics, but later changed to structural design. Marta Kindya graduated in metallurgical engineering, but later worked in telecommunications.)

Supplemental Activities

1. Invite local engineers and engineering students to discuss the profession with the class or group. A nearby university with an engineering program might be able to recommend speakers.

2. Organize a field trip to a local engineering project.

3. For materials that serve as motivational tools for students interested in engineering careers, obtain the *Engineering Guidance Materials Directory*. The directory contains information on publications, films, videotapes, slides, and tapes available from industrial, professional, and educational organizations.

(Send requests to the National Action Council for Minorities in Engineering, Inc., Three W. 35th St., New York, NY 10001; 212/279-2626.)

4. Keep a bulletin board or scrapbook with information on engineering advances and notable women engineers. Share this information with other classes, counselors, librarians, and teachers, and encourage them to be aware of these and other nontraditional career opportunities for women.

5. Help students create an engineering project. For example, using their own community as a model, they could design an emergency support system for use in the event of a disaster such as a flood or fire.

6. Have students develop a scenario 25 years in the future. In this future society, robots have significantly changed work environments. What kinds of tasks will robots perform? How will humans occupy themselves? What might be the consequences of this change in society?

7. Investigate pre-engineering summer programs that allow students to get a head start in training. Information on local programs might be available from local school boards, nearby universities, or professional engineering associations.

8. Suggest that students form an engineering club. Help them organize and plan regular activities. Encourage high school students to join their school chapter of JETS, INC. (Junior Engineering Technical Society). If the school has no JETS, INC. chapter, help students organize one. The society encourages students to explore engineering and applied science through project work and activities. Chapters operate in high schools, under the guidance of a teacher. Practicing engineers serve as volunteer technical advisers. For more information, contact the United Engineering Center, 345 E. 47th St., New York, NY 10017; 212/705-7690.

9. Have one student role-play a prospective engineering major. Another student can role-play a college admissions counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in engineering. Discuss and role-play methods of coping with direct and subtle discouragement.

Competitions

1. Discover who can build the strongest structure from a fixed amount of balsa wood, or who can turn "junk" into the most valuable creation. (Students could ask their parents to donate discarded materials, or small donations of 25-50 cents could be collected to purchase identical materials for each student.)

2. Hold an egg-dropping contest. The student who can drop a wrapped egg from a fixed height three times without breaking it wins the contest. The egg should be wrapped with no more than five sheets of legal-size mimeograph paper and two feet of cellophane tape. Begin the contest with a drop from six feet and increase the height of the two subsequent drops.

3. Encourage students to participate in the interscholastic Olympics of the Mind competition. Olympics of the Mind challenges students to undertake their own creative engineering projects. (For information, contact Dr. C. Samuel Micklus and Carole Micklus, Olympics of the Mind Association, Inc., P.O. Box 27, Glassboro, NJ 08028; 609/881-1603.)

Supplementary Materials for Students

Outstanding Women in Science: Engineering

Nance Katherine Dicciani

Occupation: Director of Research and Commercial Development in the Industrial Chemicals Division of Air Products and Chemicals, Inc., Allentown, Pennsylvania.

Education: Ph.D., Chemical Engineering, University of Pennsylvania, 1977; M.B.A., Business Management, University of Pennsylvania,1986.

Awards and honors: Villanova University, Professional Achievement Award, 1986; Society of Women Engineers, Achievement Award, 1987; Women of Influence in the Lehigh Valley.

Professional service: Member, Advisory Board, University of Virginia Chemical Engineering Department; Member, American Institute of Chemical Engineers; Senior Member, Society of Women Engineers.

Dr. Dicciani's parents were an important influence in her decision to become an engineer. "They taught me, 'if you can dream it, you can do it,'" she says.

The research she directs and supervises at Air Products and Chemicals, Inc. is aimed at creating new organic compounds useful in the manufacture of products such as herbicide, building insulation, automobile bumpers, medical equipment, furniture, and many others.

She and her research staff also work to develop novel compounds with new industrial uses, test and evaluate products, and perform a wide variety of other technical activities. "The work environment is exciting, action-filled, visionary, and intellectually stimulating," Dr. Dicciani says. "The people I work with are exceptionally bright, ambitious, goal-oriented, and fun to be around."

Of her many professional accomplishments, she is most proud of discovering a new catalyst for the production of benzene. She also developed the company's first non-cryogenic product (one which does not require very low temperatures) for the separation of air into nitrogen and oxygen, and a new product for the recovery and purification of landfill gas.

While Dr. Dicciani is enthusiastic about the opportunities available to young women in the field of engineering, she admits that achieving her goals has been difficult. "The old adage, 'A woman must be twice as good to be considered equal,' is slowly fading but not yet gone," she says. "Young women must have single-minded determination to succeed, and they must remember that consistency of performance is critical. But for those who have the courage and the will to be their best, the personal rewards and sense of accomplishment are enormous."

Engineering Interest Assessment

The following questions reflect some of the common interests of engineering professionals. If you answer yes to many of these questions, you might want to consider a career in engineering.

1. Do you like trying to figure out how things work?

   Yes _____ No _____

2. Do you ever think of ideas for new ways to do things or new uses for common objects?

   Yes _____ No _____

3. Have you ever sketched a design for a new machine or other invention?

   Yes _____ No _____

4. Have you ever drawn up plans for building projects or constructed models?

   Yes _____ No _____

5. Do you like reading charts, maps, blueprints, or diagrams?

   Yes _____ No _____

6. Are you good at mathematics and numerical problem solving?

   Yes _____ No _____

7. Do you like conducting scientific experiments?

   Yes _____ No _____

8. Have you ever spent a lot of time finding a solution to a difficult problem?

   Yes _____ No _____

9. Before starting a new task, do you like to plan how you're going to accomplish it?

   Yes _____ No _____

10. If something breaks, do you enjoy trying to repair it?

    Yes _____ No _____

11. Do you like discussing your ideas and writing reports?

    Yes _____ No _____

12. Do you enjoy learning how to use different devices such as calculators and computers?

    Yes _____ No _____

13. Do you enjoy the challenge of a new task, even if you don't understand it fully at the beginning?

    Yes _____ No _____

Career Options in Engineering

Currently, engineering has approximately 25 branches and 85 subdivisions of specialization to meet the growing demands of an increasingly technological society. The *Occupational Outlook Handbook* (U.S. Bureau of Labor Statistics 1986) lists the following specialties and occupational definitions.

Aerospace engineers design, develop, test, and help produce commercial and military aircraft, missiles, and spacecraft. They develop new technologies, work in areas such as structural design and navigational guidance, and frequently specialize in one type of aerospace product such as rockets or commercial aircraft.

Ceramics engineers work with all nonmetallic, inorganic materials, transforming ceramics and other materials into useful parts and products such as glassware, electronics, and computers.

Chemical engineers work in many phases of the production of chemicals and chemical products. They design equipment and chemical plants, and test methods of manufacturing chemical products. Because their skills are essential in many different fields, chemical engineers work in a variety of environments. Large numbers of chemical engineers work in electronics manufacturing and in biotechnology fields. They frequently specialize in a particular process such as oxidation, or in a particular product area such as rubber or plastics.

Civil engineers work in the oldest branch of engineering, supervising and designing the construction of roads, airports, tunnels, etc. There are numerous subcategories of specialization, including environmental, highway, hydraulic, soil, structural, and transportation.

Electrical and **electronics engineers** design, develop, test, and supervise the manufacture of electrical equipment such as power-generating equipment for utility plants, vehicles, and buildings. Some specialize in electronics equipment such as radar, computers, and consumer goods.

Industrial engineers determine the most effective ways for an organization to use basic elements of production: people, machines, materials, and energy. They are more concerned with people and methods of business organization than are engineers in other specialties. They help develop systems of management, production, and data processing for industry, government, and other institutions.

Materials engineers evaluate technical and economic factors to determine which of the many metals, plastics, ceramics, or other materials would function best in a specific application.

Mechanical engineers are concerned with the use, production, and transmission of mechanical power and heat. They develop and design engines and many other machines such as refrigeration devices and robots. Many mechanical engineers work in research, testing, and product design; others work in machine maintenance.

Metallurgical engineers develop new types of metals and other materials that must meet certain requirements such as weight restrictions and heat resistance. Most work in three main subcategories of metallurgy.

1. **Extractive.** Engineers who work in this area remove metal from ores and refine and alloy them to obtain useful metal.
2. **Chemical** or **physical.** Specialists in this area are concerned with the nature, structure, and physical properties of metals.
3. **Mechanical** or **process.** Engineers in this area of metallurgy are concerned with processes that help form and shape metals such as casting, forging, rolling, and drawing.

Mining engineers find, extract, and prepare minerals for use in manufacturing industries. They frequently design and supervise construction of open pit and underground mines. Because of growing environmental concerns, mining engineers sometimes supervise land reclamation procedures or work to control water and air pollution connected with mining projects.

Nuclear engineers design, develop, monitor, and operate nuclear power plants. They frequently conduct research on nuclear energy, radiation, and nuclear weapons and explore the industrial and medical uses for radioactive materials.

Petroleum engineers are primarily concerned with achieving maximum profitable recovery of oil and gas from petroleum reservoirs. They are frequently involved in the research and development of better methods to recover oil, and they often supervise drilling operations.

General Career Areas

Engineers can work in many environments and fulfill many different kinds of responsibilities.

Some general career areas for engineers are listed below.

Administration—Engineers can work as administrators, making decisions regarding human resources, finances, purchasing, or contracts.

Information systems—Some engineers work in information systems or information processing, designing and developing complex systems of information management. For example, an engineer might work for a telephone or communications company, conducting research or developing new equipment.

Production and construction—Some engineers work directly with the production of goods, others work in construction. These engineers design and implement plans to produce or construct structures such as buildings, vehicles, or other types of machines.

Research and development—An engineer might choose to work in research and development, designing and developing new or improved products, systems, processes, or techniques.

Technical services—Some engineers work in industrial settings, performing tasks such as troubleshooting, plant maintenance, safety and environmental control, testing, or evaluation.

Preparing for a Career in Engineering

Secondary Education

Mathematics—Students should take as many courses as possible, including algebra, trigonometry, geometry, and calculus.

Sciences—Physics and chemistry are essential sciences for engineering, but a strong general background in the sciences will be advantageous.

English and communications—Courses in these curriculum areas help students develop writing, speaking, and other skills that enable them to communicate effectively.

Modern foreign languages—Students should select a language sequence, preferably in French, German, Russian, or Spanish. Language proficiency is necessary for engineers, who often participate in international gatherings and follow research advances reported in foreign journals.

Additional course work—*Drafting and Design*: Introductory courses in these areas will give students a head start in basic engineering skills. *Social Sciences*: Familiarity with the fields such as anthropology, sociology, and psychology, is important for scientists concerned with human life, health, and society. *Computer Science*: Computer courses will be advantageous as engineers continue to incorporate computers in their work.

Additional factors—In evaluating the records of prospective engineering students, college admissions officers are likely to look at several factors. The overall quality of the applicant's high school preparation will be a prime consideration. An applicant's grade-point average and Scholastic Achievement Test (SAT) score are likely to be taken into consideration, but neither is likely to outweigh evidence of a solid foundation in the basic disciplines.

Postsecondary Education

According to the *Occupational Outlook Handbook*, engineering programs vary in duration and emphasis. Some engineering schools and two-year colleges have entered into an agreement whereby the college or school provides the initial engineering education and the engineering school then automatically admits qualified students. Other engineering schools have arrangements with liberal arts colleges whereby students take three years of liberal arts studies and two years of engineering studies to obtain a bachelor's degree from both the college and engineering school. Some schools offer five-year master's degree programs.

Associate degree—A student may choose to pursue a two-year associate degree program in engineering. Such programs are offered by many colleges, universities, and technical programs.

Bachelor of Science (B.S.)—A bachelor's degree in engineering requires four to five years of study. The first one to two years will consist of a core curriculum and will be followed by two to four years of specialization in one of the many branches of engineering. A bachelor's degree in engineering is acceptable for most beginning-level engineering jobs. Graduates with bachelor's degrees in science or mathematics and experienced technicians may also qualify for some engineering jobs (U.S. Bureau of Labor Statistics 1986).

Engineering technology programs—Many colleges and universities offer two- to four-year

training programs in engineering technology. These programs prepare students for practical design and production work rather than advanced theoretical scientific and mathematical work. Often called engineering technicians, these graduates usually find jobs similar to those obtained by graduates with bachelor's degrees in engineering (U.S. Bureau of Labor Statistics 1986).

Combined degrees—Engineering combines well with other disciplines. In some instances, universities offer double majors in engineering and other fields. Currently, growing opportunity exists in a wide spectrum of areas related to engineering, and the interdisciplinary combinations available in colleges and universities reflect the numerous career opportunities.

Graduate study in engineering—Graduate programs permit further specialization and generally lead to teaching or research. Graduate training is essential for faculty positions, but not necessary for entry-level jobs. Many engineers return to graduate school to learn new technologies or to qualify for promotions.

Graduate study in other fields—A bachelor's degree in engineering can be supplemented by an advanced degree in another field such as medicine, law, or business. Students who combine bachelor's degrees in engineering with advanced study in other fields can build careers in biomedical engineering, patent law, international consulting, and many other areas.

Outlook and Salaries

The U.S. Bureau of Labor Statistics (1986) reported the following findings regarding employment outlook and opportunity in engineering fields.

- Engineering is the second largest profession in the U.S., exceeded only by teaching.
- The demand for engineers (in all specialities except mining and nuclear) is expected to remain high through the mid-1990s, due to anticipated higher levels of investment in industrial plants and equipment, office buildings, other construction projects, and higher defense expenditures. Employment opportunities for engineers are expected to remain good through the mid-1990s as well, although the number of jobs and salaries will vary by area of specialization.
- Aerospace, chemical, civil, and industrial engineering are the largest specialties.
- In 1984, over half of the 1.3 million jobs held by engineers were located in manufacturing.

In addition to opportunities in traditional specialties, computer and software engineering are both rapidly growing fields that promise job opportunities for those who combine engineering with training in computer science, particularly in software development. In this decade the demand for software engineers is expected to exceed the supply (Revell 1985).

Perhaps the most reliable indicator of market demand for engineers is salaries. A bachelor's degree in engineering will command a higher beginning salary than the same degree in another field. According to the College Placement Council (1984), engineering graduates with bachelor's degrees and no experience averaged $26,300 a year in private industry. Graduates with master's degrees averaged $30,400, and Ph.D. graduates averaged $39,500.

A survey conducted by the U.S. Bureau of Labor Statistics in March 1986 indicated a mean salary range of $27,866–$79,021 for engineers; $16,882–$32,718 for engineering technicians; and $13,054–$31,004 for drafters.

A survey conducted by the National Society of Professional Engineers (1987) revealed a 4.7 percent increase in the income of engineers between 1986 and 1987, increasing the median annual income from $47,200 to $49,400.

Starting Salaries of Engineers with Bachelor's Degrees (by Specialization)

Aeronautical	$25,836
Chemical	$27,420
Civil	$27,764
Electrical	$26,556
Industrial	$25,224
Mechanical	$26,280
Metallurgical	$26,556
Mining	$24,876
Nuclear	$26,388
Petroleum	$29,568

(U.S. Bureau of Labor Statistics, 1986-87)

Most companies must compete to hire women engineers because they are presently in short supply in the job market.

An engineer with an advanced degree can earn more, and the benefits of holding an advanced degree in engineering are expected to increase in coming years, when more exclusive opportunities are expected to become available for those with advanced degrees and experience.

For More Information

Associations and Organizations

American Association of Engineering Societies, Inc., 345 E. 47th St., New York, NY 10017. (A federation of 43 engineering societies, AAES is a wealth of information on all aspects of engineering careers and practice. It publishes annual surveys of engineering salaries in industry and education, studies of supply and demand, and special reports on careers and employment.)

Junior Engineering Technical Society, 345 E. 47th St., New York, NY 10017; 212/ 664-7690. (This organization provides club guidelines and information on engineering activities.)

National Action Council for Minorities in Engineering, Inc., Three W. 35th St., New York, NY 10001; 212/279-2626.

National Society of Professional Engineers, 2029 K St. N.W., Washington, DC 20006. (A membership organization for practicing engineers, it provides information on professional issues such as ethics, registration, professional development, salaries, and legislative developments.)

Society of Women Engineers, 345 E. 47th St., Room 305, New York, NY 10017. (SWE publishes information on career opportunities and provides assistance to women engineers returning to work. It also administers several award, certificate, and scholarship programs.)

Directories of professional associations

Directory of Engineering Societies and Related Organizations. 10th edition. New York: American Association of Engineering Societies, Inc., 1982.

Encyclopedia of Associations. Denise Akey, editor. Detroit: Gale Research Company, 1987 (updated biennially).

National Trade and Professional Associations of the United States and Canada and Labor Unions. Washington, DC: Columbia Books, 1987. (Updated annually.)

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National Science Foundation. February 14, 1986. Science and Engineering (S/E) Graduates Find Increasing Opportunities for Employment in S/E Occupations. *Science Resources Studies Highlights.* NSF Publication in series, NSF 85-334.

National Society of Professional Engineers. 1987. *NSPE Professional Engineer Income and Salary Survey 1987.*

Revell, Diane B. 1985. Software Engineering. *U.S. Woman Engineer.* May/June.

U.S. Bureau of Labor Statistics 1986. *Occupational Outlook Handbook.* Washington, DC: Government Printing Offices. 1986-87 edition. Bulletin 2250.

_____. March 1986. *National Survey of Professional, Administrative, Technical and Clerical Pay.*

Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

Program 6
Geosciences

Program Summary

Geoscientists study the structure, composition, and history of the earth. Some geoscientists explore the earth to locate oil, natural gas, and other energy resources. Others support agricultural planning, helping farmers determine the patterns of erosion in their fields. A geoscientist might study how the underlying rock in a specific location will react when a bridge is built above it, or how the earth compares geologically with other planets in our solar system.

Geoscientists work in many parts of the world and in many different locales such as mines, oceans, deserts, and mountains, as well as in office buildings and laboratories.

Specializations in the geosciences are numerous, reflecting the complexity of the earth and its components. Most geoscientists specialize in a particular field.

More and more women are choosing careers in the geosciences. The program features four professional women geoscientists and several graduate students.

In order of appearance

- **Meridee Jones-Cecil**, M.S., is a seismologist for the United States Geological Survey. She studies earthquakes, particularly how, why, and when they occur, to determine safe building sites and appropriate emergency procedures.
- **Nancy Ann Brewster** works as an exploration geologist for Union Oil Company, specializing in the discovery of new oil reserves. She holds two master's degrees, one in geology and one in business management. She was recently appointed Special Assistant for Scientific Planning to the National Science Foundation.
- **Bonnie Robinson** is a production geologist for the Superior Oil Company. She works with engineers and other specialists to develop the least costly and most efficient means of extracting oil from the earth.
- **Tanya Atwater** is an internationally known geologist specializing in oceanography and plate-tectonics at the University of California–Santa Barbara. Her investigations often lead her to the ocean floor, where she studies the renewal and aging processes of the earth's crust.
- **Sandy Carlson**, a Ph.D. student in paleontology at the University of Michigan–Ann Arbor, studies three million-year-old fossils to determine the development of life through geological time.
- Two unidentified geology students are also interviewed. They discuss the value of field work opportunities and the excitement of applying what is learned in the classroom to the real world.

Several of the geoscientists mention the pleasure they derive from working in field settings. Geoscience offers opportunities to work outdoors, exploring the earth. Others mention that work in the geosciences rarely becomes routine. They have an enthusiasm for exploration and discovery.

The program reviews recommended course work for high school and college preparation for a career in the geosciences. Interested students should have logical reasoning skills, enjoy solving problems, and be able to visualize in three dimensions.

High school students should develop a strong background in earth science, physics, and chemistry. In addition, they should take three to four years of mathematics. Courses in English, communications, computer science, and foreign languages are also recommended.

In their first two years, college students majoring in the geosciences should complete basic requirements in the humanities, mathematics, and sciences. Most geoscience majors concentrate on advanced geoscience courses and field work during their junior and senior years.

Geoscientists share an interest in science and mathematics and a wonder of the earth and its processes, history, and composition.

Did You Know?

- While only 5 percent of geologists working today are women, the number of women earning degrees in the geosciences has increased substantially in the last 10 years. Based on this increase, the number of women in the geosciences work force could increase as much as 20–25 percent in the next decade (Crawford et al., 1987).

Percentage of All Geoscience Degrees Awarded to Women

	1972	1980	1986
B.S.	23	26	24
M.S.	10	20	24
Ph.D.	7	10	22

American Geological Institute, 1987
Survey of Geoscience Degrees Earned

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Geosciences Interest Assessment on page 52, and then proceed with an introductory discussion.

1. What type of work might a geoscientist perform?
2. Do geoscientists spend all their time outdoors?
3. What aspects of the geosciences appeal to you?
4. What type of person might be a successful geoscientist?
5. What type of education is required?
6. Can women geoscientists manage both a career and a family?
7. What special problems do you think women geoscientists might face?

After the Program

Possible answers to the following discussion questions are in parentheses.

1. What aspects of geology do you find interesting? (working in a variety of locations, traveling, exploring the earth, performing scientific research)
2. Describe the type of work that various geoscientists perform. (Geoscientists specialize in many different areas: seismologists study earthquakes, exploration geologists search for undiscovered oil reserves, production geologists help engineers and other specialists extract oil from the earth or ocean floor, paleontologists study ancient life forms. For a list of specializations see page 53.)
3. What courses would best prepare a high school student interested in a career in the geosciences? (A strong background in mathematics and science is recommended. Courses in earth science and astronomy are highly recommended. Courses in communications, computer science, English, and foreign languages are also required.)
4. Why is a strong mathematics background important? (Mathematics is an important tool in geoscientific research. Geoscientists must be able to use logical reasoning skills, solve complex problems, and visualize objects in three dimensions.)
5. Why are good communications skills valuable to a geoscientist? (They often write reports, articles, and grants; they must be able to consult and communicate with scientists and other professionals.)
6. What are some of the settings in which geoscientists work? (laboratories; offices; field sites such as mountains, ocean floors, and oil rigs)
7. What level of education do most geoscientists possess? (Most possess at least a bachelor's degree. Many geoscientists find it necessary to earn a master's or Ph.D. degree in order to pursue a career with opportunities for growth and a good salary.)
8. Can a woman geoscientist manage a career and family life at the same time? (Yes, with planning and support. Several of the featured geoscientists are married and have children. They stress the importance of sharing the responsibilities of home and family with their spouses.)

Supplemental Activities

1. Invite professional geoscientists and students to speak about their careers and training. For help identifying potential speakers, contact local (city or state) geoscience societies, state or federal geoscience agencies, or local university geoscience departments. Useful references include the American Geological Institute's *Directory of Geoscience Organizations*, the *U.S. Geological Survey Geologic Division*, and the *U.S. State Surveys*, available annually in the October *Geotimes* or separately as a reprint.

2. Create a career center or bulletin board with information on careers in the geosciences. Collect magazine and newspaper clippings. Write to professional organizations such as the Association for Women Geoscientists for material. Share this information with other classes, counselors, librarians, and teachers, and encourage them to be aware of these and other nontraditional career opportunities for women. (For information about professional organizations and resource materials see pages 54-55.)

3. Invite an academic adviser or professor of geology from a local college or university to speak about academic preparation, career options, and work-study programs available to students.

4. Take a field trip to a site of geological importance. For information about local fossil deposits, mines, faults, or other interesting geological sites, contact the geology department at a nearby university or college.

5. Obtain a guide to rock and mineral identification and have students identify rocks and minerals commonly found in their area. (A good, inexpensive guide is *Golden Guide: Rocks and Minerals* by Herbert Zim and Paul Shaffer, Golden Press, New York.)

6. Collect a variety of rocks. Conduct a simple test to identify which of the rocks contain the minerals calcite or dolomite. Test the rocks by placing a drop of a solution of hydrochloric acid which has been diluted with water on each one. Substances that contain either of these minerals, such as limestone or chalk, will make the solution fizzle.

7. Take a field trip to a natural history museum.

8. Have one student role-play a prospective geology student. Another student can role-play a college admissions counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in geology. Discuss and role-play methods of coping with direct and subtle discouragement.

9. Develop research projects that involve the geoscientific investigation of your local area. Students could research the land planning and development of their city or town. (Why is it located where it is? How did the present street plan develop?) Students might map the local water sources, including processing stations, and make geochemical comparisons of the water composition from varying locations. Students might also collect meteorological data on their region and examine the influence of weather on their environment.

10. Have students make a topographic map of a local park or area close to the school.

11. Develop a problem-solving activity involving maps. Using topographic maps of the local area, have students locate a shopping center, power plant, or other significant site.

12. Choose a geological site such as a river, mountain, delta, lake, or island. Have students research the site's history from its formation to its present state. Based on this information, have students project how the site will change in the future.

Supplementary Materials for Students

Outstanding Women in Science: Geosciences

Occupation: Administrator of Special Programs and Proposals at the American Geological Institute (AGI), Alexandria, Virginia.

Education: M.A., Earth Science, Wesleyan University,1981.

Awards and honors: Minority Participation Scholarship, American Geological Institute, 1977.

Professional service: President, Association for Women Geoscientists, 1988–89.

Marilyn J. Suiter

Maryilyn Suiter began her career teaching science in the Philadelphia Public Schools. Her involvement in geosciences began when she attended a NSF earth science course for teachers. "I found the course intriguing enough to compel me to go back to school for my earth science teaching certification," she says.

Later, a field trip to the Yellowstone Bighorn Research Association field camp in Montana inspired her to change careers. "Driving through Canada to the camp was really an exciting experience," she recalls. "Living in a log cabin in the Bighorn Mountains was just wonderful; that was probably the clincher."

While studying to obtain her B.A. and M.A. degrees, she worked as a geologist for the U.S. Geological Survey. Later, she also worked as an exploration geologist for an oil and gas company, locating oil and gas and supervising their extraction from sites in Kansas, Colorado, and the Oklahoma Panhandle.

Suiter's current responsibilities at AGI involve directing programs and recommending new projects that encourage the participation of underrepresented populations in geoscience.

"My career has involved humanitarian phases such as teaching and technical phases such as working for the U.S. Geological Survey," she explains. "I enjoy my current position because I'm able to combine these phases, and my work affects a much larger audience.

"For those considering a career in geoscience, a good background in mathematics is important," Suiter advises. "The math and science are do-able; don't get frustrated if it takes a bit of extra work. It's worth it."

Suiter cautions young women not to presume that they will experience bias or discrimination: "Develop a sound awareness of who you are, your values, your weak and strong points. With clear self-perception you will have the self-confidence necessary to counter most problems."

Geosciences Interest Assessment

The following questions reflect some of the common interests of geoscientists. If you answer yes to many of these questions, you might want to consider a career in the geosciences.

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1. I find some of these occupations attractive: biologist, physicist, chemist, engineer.

   Yes _____ No _____

2. I enjoy some of these activities: traveling, hiking, mountain climbing, collecting rocks and minerals.

   Yes _____ No _____

3. I enjoy solving puzzles.

   Yes _____ No _____

4. I sometimes question what I read.

   Yes _____ No _____

5. I enjoy working as a part of a team.

   Yes _____ No _____

6. I can adapt easily to different people and environments.

   Yes _____ No _____

7. In school I enjoy mathematics and science courses such as algebra, calculus, chemistry, and physics.

   Yes _____ No _____

8. I sometimes wonder how the earth came to be the way it is.

   Yes _____ No _____

9. I enjoy reading and drawing maps.

   Yes _____ No _____

10. I enjoy giving presentations and writing reports.

    Yes _____ No _____

11. I have the ability to visualize objects in three dimensions.

    Yes _____ No _____

12. I like solving problems that require "detective" work and finding evidence that enables me to draw sound conclusions.

    Yes _____ No _____

13. I enjoy activities that require observation, description, and classification such as bird watching and stamp collecting.

    Yes _____ No _____

Career Options in the Geosciences

There are many specializations in the geosciences. Some common career options for geologists are listed below.

Earth Materials

Economic geology involves the investigation of ore-forming minerals and fuel deposits that can be mined or developed.

Engineering geology is the use of engineering techniques to determine the feasibility of constructing dam sites, tunnels, and highways.

Geochemistry is the investigation of the nature and distributions of chemical elements in rocks and minerals.

Marine geology is the study of the nature and composition of the ocean floor and continental shelves.

Mineralogy is the analysis, classification, and description of minerals.

Petroleum geology is the study of oil and natural gas deposits in the attempt to locate new drill sites.

Petrology is the analysis, classification, and description of rocks.

Planetary geology is the study of the surfaces of the moons and planets in our solar system.

Earth Processes

Geomorphology is the investigation of earth processes such as the development of landforms.

Geophysics is the study of magnetism, gravity, and heat flow patterns within the earth.

Hydrology is the study of the circulation, distribution, and properties of water.

Seismology is the study of the causes and effects of earthquakes.

Structural geology concerns the processes that form the earth's crust and its characteristics such as fracturing and folding.

Volcanology is the study of the causes and effects of volcanic activity.

Earth History

Geochronology is the calculation of the rate of decay of radioactive elements in rocks to determine their ages.

Paleontology is the study of fossils in the attempt to describe the nature and development of life through geologic time.

Stratigraphy is the investigation of the thickness, shape, and distribution of layered rocks and their mineral and fossil content.

General Career Areas

Private Industry—Private industries employ over half of all geoscientists in the U.S. Most geologists work for petroleum companies, mining companies, or service companies that perform special technical jobs for these industries (American Geological Institute 1987).

Government—The federal government is the second-largest employer of geoscientists. Approximately 12 percent of all working U.S. geologists hold government positions. The following agencies are primary sources of opportunity for geoscientists: U.S. Geological Survey, Soil Conservation Service, Bureau of Land Management, National Park Service, Bureau of Mines, U.S. Forest Service, and the Army Corps of Engineers. In addition, most state governments employ geologists to work for geological surveys. Some city and county governments also employ geoscientists (AGI 1987).

Education—Because many states now require that earth science education be included in the pre-college curriculum, new teaching opportunities are available for geoscientists. While earth science is commonly taught at the junior high school level, it is now part of many K-6 curricula and is also taught as an advanced science in high school. Approximately 8 percent of all working geologists now hold academic appointments. Opportunities in academe for women geoscientists are expected to increase in the next decade (AGI 1987).

Consulting—Some geoscience professionals with specializations in exploratory geology, petrology, and other applied fields offer consultation to private industries. They are usually employed on contracts as project consultants.

Preparing for a Career in the Geosciences

Secondary Education

Mathematics—Suggested courses: algebra, geometry, trigonometry, calculus, and statistics. Calculus is strongly recommended.

Sciences—The geosciences apply the principles and techniques of virtually all physical sciences to the study of the earth. Therefore, students should take as many science courses as possible, including biology, chemistry, and physics. Earth science and astronomy, if available, are strongly recommended.

English and communications—Geoscientists must express themselves clearly through written and oral reports and must be able to communicate effectively with their co-workers.

Modern foreign languages—Knowledge of at least one and preferably two languages will be advantageous. Geoscientists often travel to foreign countries to conduct field research, attend international conferences, and read research reports in foreign journals.

Additional course work—*Computer science*: Computers are becoming increasingly integral in geoscientific research. *Advanced placement courses*: Advanced placement courses in mathematics, sciences, and foreign languages can lead to early college credit.

Postsecondary Education

Bachelor of Science (B.S.)—The bachelor's degree requires four years of lecture and laboratory instruction in basic geology courses such as mineralogy, petrology, stratigraphy, paleontology, and structural geology. Additional courses in mathematics and computer science, as well as advanced chemistry, physics, biology, economics, and government, are suggested. Most students will also be required to enroll in a special summer course in geological field work.

Master of Science (M.S.)—A master's degree is usually required for beginning research positions or higher-paying positions in the geosciences. The M.S. usually requires two years beyond a B.S. and consists of advanced courses in geology and related fields. Students usually select an area of specialization.

Doctor of Philosophy (Ph.D.)—A Ph.D. is required for advancement in college teaching and for most high-level research positions.

Related fields—Some students choose to combine their geoscience degrees with other areas of interest such as another science specialty, business management, secondary education, journalism (for technical writers and editors), and law.

Outlook and Salaries

Unless specified otherwise, the following job and salary statistics were compiled by the American Geological Institute.

- Students graduating with degrees in the geosciences will face a competitive job market due to decreasing opportunities in the petroleum and minerals industries. A survey conducted for the American Geological Institute revealed a 4 percent unemployment rate for geoscientists (AGI 1987).
- Supply and demand in the geosciences job market is expected to continue to be imbalanced in the near future. A 1987 survey suggests that the number of viable employment opportunities for geoscientists in 1987 was far less than the number of 1986 geoscience graduates seeking positions (AGI 1987).
- A near-term employment forecast estimates that 700–900 of approximately 10,000 U.S. geoscience graduates were hired by all U.S. employers in 1987. Approximately 300–400 graduates were hired by the petroleum industry. The mining/minerals industry hired 150 to 250 graduates (AGI 1987).
- The median annual income for employed geoscientists is approximately $50,000. Those working in the oil and petroleum industries usually earn more. Those working in education and local government usually earn less (AGI 1987).
- As in most scientific professions, women geoscientists still earn less than their male counterparts at all stages of their careers. In 1986 a male geoscientist with less than one year of professional experience earned an average salary of $22,600, while an equivalent female geoscientist earned $14,800. A male geoscientist with five to nine years of experience earned an average of $34,400, while his female counterpart earned $31,700 (National Science Foundation 1988).

For More Information

Associations and Organizations

American Geological Institute, 4220 King St., Alexandria, VA 22302; 703/379-2480 or 800/336-4764. (Provides public information, education, publications, and services for the geoscience community.)

Association for Women Geoscientists, 10200 West 44th Ave., Ste. 304, Wheat Ridge, CO 80033; 303/422-8527. (Aims to encourage the participation of women in the geosciences. Provides career information and conducts scholastic awards program for outstanding students in the geosciences.)

U.S. Geological Survey, Public Inquiries Office, Department of the Interior, Menlo Park, CA 94025; 415/329-4396.

Geological Society of America, P.O. Box 9140, 3300 Penrose Pl., Boulder, CO 80301; 303/447-2020.

History of Earth Sciences Society (HESS), E-501, Museum of Natural History, Washington, DC 20560; 202/343-3232.

Rollin' Rock Club, 1155 E. 42nd St., Odessa, TX 79762. (Publishes educational materials and trading information for those interested in gems, minerals, the earth sciences, and lapidary arts.)

Publications of the American Geological Institute

Earth Science. A quarterly magazine for all students of the earth. $8/year.

Careers in Geology. A career-guidance pamphlet for anyone interested in the geological profession. Single copies free; bulk orders $20/100.

References

American Geological Institute. 1987. *Summary: North American Survey of Geoscientists, U.S. Section. Survey Results and Forecast of Employment Trends.*

Crawford, M.L., J.B. Moody, and J. Tullis. 1987. Women in Academia: Students and Professors Revisited. *Gaea* 10:2.

National Science Foundation. January, 1988. *Women and Minorities in Science and Engineering*. NSF 88-301.

Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

Indiana Geological Survey

A geology graduate student pauses for a break during a field trip to measure sand and gravel beds for a mapping project.

Indiana Geological Survey

A woman geologist and her colleagues examine cores (long, thin samples of subsurface rock) for potential mineral deposits.

Program 7
Physics and Astronomy

Program Summary

Physicists and astronomers are curious about the universe. They share a fascination with the way things work and a desire to find the answers to some of the most difficult questions ever asked. Often at the forefront of scientific discovery, they study many aspects of the universe from the smallest particles of matter to the most remote galaxies.

Women have been involved in important discoveries and events in physics and astronomy throughout history. Five famous women physicists are featured in the program.

French physicist Marie Curie (1867–1934) received two Nobel Prizes (1903 and 1911) for the discovery of polonium and radium.[1]

Lise Meitner (1878-1968), an Austrian, helped pioneer the development of nuclear energy through her research in nuclear fission.[2]

German-born physicist Maria Goeppert Mayer (1906-1972) shared the 1963 Nobel Prize in physics for her research concerning the shell structure of atomic nuclei.

Chien-Shiung Wu (1912?–), an American experimental physicist, helped disprove the law of conservation of parity,[3] proving that the physical laws that govern some systems of molecules are different from the laws that govern the mirror images of these systems. Her discovery suggests that nature is not always symmetrical.

During the space shuttle mission of June 1983, American astronaut Sally Ride (1951–) became the first woman flight engineer to travel into space. Ride, who holds a Ph.D. in astrophysics, performed experiments outside the *Challenger*, using a remote manipulator arm.

Physicists and astronomers are interested in the laws and properties of matter, motion, heat, light, and electricity. Often their research contributes practical information that can be applied to problems such as improving the efficiency of a nuclear power plant. Other physicists and astronomers contribute to our basic understanding of the universe with discoveries about the life cycles of stars and galaxies, atomic theory, and other physical phenomena.

The program presents five women who have made successful careers in physics and astronomy, and two students who are currently pursuing degrees in physics.

In order of appearance

- **Linda Powers** is a theoretical physicist working with KMS Fusion, a laser physics research laboratory in Ann Arbor, Michigan. She holds a master's degree in mathematics and is finishing a doctorate in plasma physics.
- **June Rooks** holds a master's degree in physics. She creates and tests flight simulations for aircraft at the U.S. Naval Weapons Center in California.
- **Betsy Turner** works in a nuclear physics laboratory at Emory University in Atlanta, monitoring the effects of radiation from a nuclear power plant. She holds a bachelor's degree in physics and a master's degree in medical science.
- **Gayle Ater** teaches high school physics in Louisiana. She holds a master's degree in education and physics and has received national awards for excellence in teaching.
- **Anne Cowley** holds a Ph.D. in astronomy and serves on the faculty of Arizona State

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[1]Polonium (Po) and radium (Ra) are highly radioactive metallic elements. Both occur naturally in uranium ores such as pitchblende.

[2]Nuclear fission is the process of splitting the nucleus of an atom into two parts, thereby creating a large amount of energy. The continuous fissioning of atoms, also called a chain reaction, is the energy source of all present nuclear reactors.

[3]Once believed to be a natural law of physics that applied to all events, conservation of parity concerns the symmetry between an event and its reflection: when parity is conserved, an event and its mirror image appear identical to an observer. While all ordinary mechanical and electrical systems demonstrate conservation of parity, physicists have discovered that parity is not conserved in a specific type of nuclear event.

University. Her research led to the discovery of a black hole.[4]

- Two physics students at the University of Michigan, **Anne Cummings** and **Ellen Montague**, discuss their educational experiences.

Physicists work in a variety of settings: federal and state agencies, industry, hospitals, and universities. Astronomers usually work for government agencies and universities.

The program reviews recommendations for high school and college preparation for physics and astronomy careers. High school students should prepare by developing a strong foundation in mathematics and science. Courses in astronomy and computer science are highly recommended.

Most physics and astronomy majors begin with general physics courses and progress to advanced courses and laboratory work in specialized branches of physics such as mechanics, electronics, and thermodynamics.

Physicists and astronomers often mention the excitement of making new discoveries, finding solutions to difficult problems, and asking questions about the nature of the universe. Many professionals in these fields find their creativity limited only by their imaginations.

Did You Know?

- In 1986, approximately 7 percent of the 72,600 physicists and astronomers employed in the U.S. were women. Of the 44,300 physicists and astronomers employed in the U.S in 1976, 4 percent were women (National Science Foundation, January 1988).

- In 1986, approximately 14 percent of all bachelor's degrees granted in physics were awarded to women. Sixteen percent of all terminal master's degrees and 8 percent of all doctorates in physics were awarded to women (Ellis 1986–87).

[4]Black holes are objects with intensely strong gravitational force which astronomers believe exist in space. Black holes are probably formed when a large star collapses and compresses until its light cannot escape; a star in this condition appears as a "black hole" in space.

Before the Program

You could choose to conduct an introductory discussion using the following questions, or have students first complete the Physics and Astronomy Interest Assessment on page 61, and then proceed with an introductory discussion.

1. What type of work might a physicist perform? An astronomer?
2. What advantages might a career in physics or astronomy offer?
3. How much education is necessary?
4. Where might a physicist or astronomer work?
5. Can a woman physicist or astronomer successfully combine her career with family life?

After the Program

1. How are physics and astronomy related? (Both disciplines seek to understand the physical nature of the universe. Astronomy is generally considered to be a subfield of physics. Astronomy requires a background in physics. Both require sound knowledge of mathematics.)
2. Who are some famous women physicists mentioned in the program? (Marie Curie discovered radium and polonium; Lise Meitner participated in early research in nuclear physics; Maria Goeppert Mayer developed a model describing the shell structure of atomic nuclei; Chien-Shiung Wu proved that nature is not always symmetrical in her theory of nonconservation of parity; Sally Ride was the first American woman to explore space; Anne Cowley discovered a black hole.)
3. How have physicists influenced the way we live today? (The work of physicists led to the development of microwave technology, transistors, televisions, computers, telephones, and many other technological advances.)
4. How might physics be applied to health and medical issues? (Betsy Tanner monitors nuclear radiation to prevent health problems. Other physicists are concerned with the effects of x-ray and ultrasound equipment on human health. Some are involved with the

development and use of laser technology for surgery, and others work in radiation therapy.)

5. Why is a good background in mathematics important to physicists and astronomers? (Mathematics is the language used by physicists and astronomers to communicate their ideas and observations. For example, measurement provides essential data in both fields.)

6. What kind of work schedule might a physicist or astronomer follow? (Physicists tend to work a regular day in laboratories, classrooms, or offices. Astronomers can also expect fairly regular hours, although they may travel to observatories occasionally to conduct field studies and work through the night gathering data. Physicists and astronomers sometimes work long hours to complete a research project.)

7. What are some of the tools an astronomer uses to make observations of the sky? (In addition to the telescope, astronomers use radioscopes to measure wavelengths of high energy electrons moving at the speed of light. Spectroscopes enable them to see the spectrum of a star and thereby determine its chemical composition. Infrared detectors help astronomers determine newly formed stars. Computers are also integral tools in astronomy.)

8. How should a high school student prepare for a career in physics or astronomy? (Mathematics is especially important: students should take as many courses as possible as early as possible. Courses in physics and other sciences are highly recommended. English, humanities, social sciences, and foreign languages are usually required for college entrance. Shop and electronics courses are also advantageous.)

Supplemental Activities

1. Invite local physics and astronomy professionals and students to discuss their careers, research, education, and training.

2. Help students form a physics or astronomy club and plan regular activities. Encourage high school students to join their school chapter of JETS, INC. (Junior Engineering Technical Society). If the school has no JETS, INC. chapter, help students organize one. The society encourages students to explore engineering and applied science through project work and activities. Chapters operate in high schools, under the guidance of a teacher. Practicing engineers serve as volunteer technical advisers. For more information, contact the United Engineering Center, 345 E. 47th St., New York, NY 10017; 212/705-7690.

3. Organize a field trip to a research laboratory where physicists or astronomers work.

4. Plan a trip to a planetarium or observatory. Ask a local astronomer to accompany students, or arrange for a special guide to be assigned to your group at the site.

5. If computers are available, arrange for students to have access to software programs that introduce concepts in physics and astronomy.

6. Encourage students to read articles about physics and astronomy in magazines such as *Physics Today*, *Astronomy*, and *Sky and Telescope*. If your students are less advanced, select more general science magazines such as *Discover*, *Science*, *The Sciences*, *Scientific American*, and *Science Digest*. Conduct a discussion about the latest advances in physics and astronomy.

7. Review television programming guides for the dates and times when relevant science programs such as *Mr. Wizard's World*, *3-2-1 Contact*, and *Nova* will be broadcast in your area. Remind students to watch these programs. Conduct a follow-up discussion.

8. Keep a bulletin board or scrapbook about women in physics and astronomy. Have students contribute articles about women scientists and their contributions, current physics and astronomy news, and information about career opportunities. Share this information with other classes, counselors, librarians, and teachers, and encourage them to be aware of these and other nontraditional career opportunities for women.

9. Suggest that students role-play a woman physicist or astronomer and her husband as they decide how to divide cooking, child care, and other family and household responsibilities.

10. Have one student role-play a prospective physics or astronomy major. Another student can role-play a college admissions

counselor, adviser, high school teacher, friend, or parent who is consciously or unconsciously discouraging the student from pursuing a career in physics or astronomy. Discuss and role-play methods of coping with direct and subtle discouragement.

11. Investigate summer programs that enable students to get a head start in physics or astronomy. Information on programs may be available from local school boards, nearby universities, or professional science associations.

12. Help students conduct experiments that demonstrate fundamental laws of physics or arrange for them to visit a high school or college physics course in which experiments are being conducted.

A Demonstration

Astronomer Annie Jump Cannon (1863–1941) discovered 300 variable stars, five new stars, and a double star. She became known as "the census taker of the sky" for her classification of nearly 300,000 stars. She was able to compare and classify stars according to spectral type, brightness, and distribution by studying their spectra (bands of colored light) with a spectroscope.[5]

Have students read about and discuss Cannon's work. Conduct a demonstration to illustrate how Cannon studied the stars with a spectroscope. A spectroscope might be borrowed from the high school physics laboratory, purchased from an optics supplier, or constructed according to the following instructions.

How to make a spectroscope

Materials: a shoe box, a piece of diffraction grating large enough to cover a one-inch square surface, tape.

The diffraction grating can be obtained commercially, or a reasonable facsimile can be made at home. To make the diffraction grating, pour clear glue on an old record. Allow the glue to dry, and peel it off the record surface.

Directions: (1) Cut a slit (about one by one-eighth of an inch) in one end of the shoe box, and a one-inch square in the other end. (2) Place diffraction grating over the square opening and secure it with tape. (3) Tape the box lid shut.

Viewing light through a spectroscope

Step 1. Shine a flashlight through a prism onto a sheet of white paper. Demonstrate and explain how the prism separates the white light into different colors of the spectrum.

Step 2. Once students understand this concept, they can use the spectroscope to observe differences in light from different sources. Have them pay attention to the brightness of the various colors in the spectrum. Explain that they might have to look carefully: the variation in brightness may be subtle.

Step 3. Ask them what conclusions can be drawn from the variations in brightness and color. Have them take notes and compare their observations.

Students examine an industrial robot to see how physics is applied in the design of mechanical and electronic devices.

[5] A spectroscope is an optical device for observing the spectrum of light or radiation from a given source. Most commercial spectroscopes consist of a chamber with a slit through which light passes, a lens, a prism, and, in some cases, a telescope through which the spectrum is viewed.

Supplementary Materials for Students

Outstanding Women in Science: Physics and Astronomy

E. Margaret Burbidge

Occupation: Professor of Astronomy, Director of the Center for Astrophysics and Space Sciences at the University of California, San Diego.

Education: Ph.D., Astronomy, University of London,1943.

Awards and honors: Warner Prize in Astronomy, 1959; Bruce Gold Medal of the Astronomical Society of the Pacific, 1982; American Astronomical Society, Russell Lectureship,1984; National Medal of Science,1984.

Professional service: President, American Astronomical Society, 1976–1978; President, American Association for the Advancement of Science, 1982; Member, American Academy of Arts and Sciences, 1969; Member, National Academy of Sciences, 1978; Eleven honorary degrees.

Dr. E. Margaret Burbidge is an observational astronomer. She studies active galaxies and quasars, which are luminous, energy-emitting objects located at the center of some distant galaxies. She employs telescopes, computers, and spectroscopes to determine the physical properties, energy sources, and radiation mechanisms of these objects. She is currently a co-investigator on a team of scientists developing a Faint Object Spectrograph for NASA's Hubble Space Telescope.

With encouragement and help from a supportive professor, Dr. Burbidge excelled in her graduate studies at the University of London. After graduating, she conducted research at the University of Chicago Department of Astronomy, the Yerkes Observatory, the Enrico Fermi Institute of Nuclear Studies, and the California Institute of Technology before accepting her current appointment.

Dr. Burbidge and her husband, Dr. Geoffrey Burbidge, also an astronomer, have worked together on research projects frequently during their marriage of 40 years. Their enduring professional collaboration and the excitement of working with young scientists and graduate students are among the most rewarding aspects of her career.

Dr. Burbidge has worked throughout her professional life to promote equal opportunities for women in astronomy. She encourages young women who are interested in astronomy to prepare for their futures now. "Study math and physics, read popular books on astronomy, and perhaps join an amateur 'star-watchers' club," she suggests. Persistence is a quality Dr. Burbidge counsels young women to cultivate when they embark on a career in science: "If you meet discrimination or discouragement, persist in your goals and find ways to work around the problems."

Physics and Astronomy Interest Assessment

The following questions reflect some of the common interests of physicists and astronomers. If you answer yes to many of these questions, you might want to consider a career in physics or astronomy.

1. Are you intrigued by the unknown?

   Yes _____ No _____

2. Would you like to look at the moon through a telescope?

   Yes _____ No _____

3. Are you curious about how things work? Do you ever take things apart and put them back together?

   Yes _____ No _____

4. Are you interested in making discoveries to advance present knowledge of the universe?

   Yes _____ No _____

5. Do you often watch science shows on television?

   Yes _____ No _____

6. Have you ever worked or experimented with magnets, mirrors, floating and sinking objects, bicycle gears, or simple machines like pulleys and levers?

   Yes _____ No _____

7. Do you like to think about why things happen and try to find logical explanations?

   Yes _____ No _____

8. Are you mechanically inclined?

   Yes _____ No _____

9. Do you enjoy mathematics?

   Yes _____ No _____

   Science?

   Yes _____ No _____

10. When you are working on an interesting problem, do you find it difficult to stop before you've reached a solution?

    Yes _____ No _____

11. Have you ever tried to come up with new inventions?

    Yes _____ No _____

12. Do you like to tackle jobs in an orderly way, one step at a time?

    Yes _____ No _____

13. Are you interested in working with computers?

    Yes _____ No _____

Career Options in Physics and Astronomy

Physics

All physicists are concerned with the nature and behavior of matter and energy. Whether they work in universities, government laboratories, or private industry, most conduct research in a specialty area within one of many branches of physics. The following are some major branches of physics and examples of their practical application.

Acoustical physics is the study of sound and its transmission, including shock and vibration, underwater sound, and speech. Among the contributions of acoustical physicists are the design of symphonic auditoriums, the development of the stereo tape deck, and the ultrasound scanner used in diagnostic medicine.

Atomic and molecular physics concern the interaction of electrons and nuclei in atoms, and the combination of atoms into molecules. Research in these areas has provided assistance in the manufacture of chemicals and pharmaceuticals and enabled identification of unknown materials.

Biophysics is the application of the ideas and methods of physics and chemistry to the study of living organisms. Investigations focus on understanding DNA, the effects of x-ray and nuclear particles on cells and tissues, and the conduct of nerve impulses.

Electronics involves the study, design, and application of devices that operate on the basis of the characteristics and behavior of electrons. Some contributions of this specialization are television, radar systems, and telephones.

Electrodynamics is the study of electrical and magnetic phenomena. Physicists working in this area have helped design huge generators capable of providing electricity for heating, lighting, and air-conditioning.

Fluid physics concerns the forces and motions of uncharged liquids and gases. Physicists in this specialization have contributed to the development of streamlined vehicles and to the design of the jet engine.

Geophysics applies the principles of physics to the study of the earth. Geophysicists have contributed methods of more efficient petroleum production. Others have studied the dynamics of earthquakes.

Medical physics applies the principles and techniques of physics to the problems of medicine. Physicists in this specialty have contributed medical diagnostic techniques and equipment such as x-rays, radioisotopes, and other scanning devices.

Nuclear physics is the study of the atomic nucleus. Contributions include nuclear energy and radiation therapy.

Optical physics is the study of light. Optical physicists have contributed to the use of lasers in eye surgery, tool manufacture, fusion power, and holography.

Plasma physics is the study of the behavior and use of high-temperature ionized gas. Plasma physicists are working toward the development of controlled thermonuclear energy.

Solid state physics is the study of the crystallographic, electronic, and magnetic properties of solids, primarily of crystalline solids. Physicists working in this area have helped to produce the transistor, integrated circuit, and computer memory.

Space and planetary physics is the study of the regions of space between the planets. Nuclear particles, atoms, molecules, meteorites, and radiation pass through these regions. Physicists in this specialty have contributed to more accurate weather forecasting and to the increased sophistication of communications satellites.

Thermodynamics is the study of different forms of energy and of the process of conversion from one form to another. Thermodynamics has helped create efficient engines and microwave ovens.

Other major branches of physics

Cryogenics is the study of extremely low temperatures.

Health physics is the development of technologies and methods of protecting people who work with or near radiation.

Mathematical physics is the study of mathematical systems that describe physical phenomena.

Mechanics is the study of the behavior of objects and systems in response to various forces.

Particle physics or **high-energy physics** is the study of the behavior and properties of elementary particles.

Quantum physics is the study of quantum theory, which deals with the interaction of matter and electromagnetic radiation.

Astronomy

Astronomers study the stars, planets, and other astronomical objects and phenomena to understand the nature and origin of the universe. Astronomy is generally considered to be a subfield of physics.

Most astronomers are also **astrophysicists**: they apply the principles of physics and mathematics to questions about astral objects and phenomena.

The following are some specializations within astronomy.

Observational astronomers specialize in observing astronomical objects and phenomena using sophisticated computers and telescopes.

Theoretical astronomers use the principles of physics and mathematics to determine the nature of the universe.

Stellar astronomers specialize in the study of stars.

Solar astronomers study the sun and related phenomena.

Planetary astronomers study the nature and conditions of the planets.

Cosmologists study the structure and history of the universe as a whole.

General Career Areas

Research—Graduates with advanced degrees in physics, astronomy, or a combination of related degrees possess the qualifications to conduct research in their areas of specialization.

Physicists conduct research on an enormous number of subjects in a variety of settings, including government, industrial, and university laboratories. Astronomers usually conduct research in a university or government laboratory.

A Ph.D. is generally required of those who conduct research; however, some positions in private industry and government institutions are available to those with master's degrees.

Teaching—Many people with backgrounds in physics and astronomy teach in public and private schools, universities, and government institutions. A Ph.D. is usually required for academic teaching positions; however, some two-year colleges will hire physicists and astronomers with master's degrees. Those who teach in large academic institutions usually combine teaching and research in their careers.

Inspection and product control—A small number of physicists conduct product inspection, testing, and supervise quality control in industry.

Consulting—A few physicists help supervise projects related to their specializations in a number of different settings such as hospital, private industry, and government laboratories.

Preparing for a Career in Physics and Astronomy

Secondary Education

Mathematics—Mathematics courses are especially important because they provide the ground rules for computation—an integral part of physics and astronomy. Students should take as many courses as possible, including algebra, trigonometry, geometry, and calculus.

Sciences—Physics courses are essential, but a strong general background in the sciences is also important. If astronomy courses are not available at the high school level, students should read science magazines and view relevant science programs whenever possible. Computer science is also important. Computers have become essential tools in physics and astronomy.

English and communications—Courses in these curriculum areas help students develop writing, speaking, and other skills that will enable them to communicate effectively with future colleagues and students.

Modern foreign languages—Knowledge of at least one and preferably two languages will be advantageous. Language proficiency is necessary for physicists and astronomers, who often participate in international gatherings and

follow research advances reported in foreign journals.

Additional course work—*Shop and electronics*: These courses will help familiarize students with many of the skills and techniques they will use in research. *Social sciences*: Familiarity with the fields of anthropology, psychology, and sociology will help students become familiar with the issues and problems of society.

Postsecondary Education

Bachelor of Science (B.S.)—Students will take courses in various branches of physics: mechanics, electricity and magnetism, thermodynamics, astronomy, modern physics (atomic, nuclear, solid state) and electronics, among others. Courses in mathematics will also be required. Chemistry and biology are electives that might enhance career options.

Students who choose to major in astronomy may also want to take courses in related areas such as geology, geophysics, planetary atmospheres, computer science, optical instrument design, and electronic data acquisition systems.

Internships and special learning opportunities—Additional learning opportunities are often available to undergraduate students through summer programs sponsored by government and private industry. Summer opportunities may also be available at universities; students are sometimes able to work with faculty members on research projects.

Master of Science (M.S.)—Graduate study is essentially a prerequisite for students who want to conduct research. In graduate school, students will focus on one branch of physics or a subfield of astronomy. Earning a master's degree in physics usually requires two to three years of advanced courses and directed research. Astronomy graduate students may be required to spend part of their graduate education working at an observatory.

Doctor of Philosophy (Ph.D.)—A Ph.D. is required for advancement in college teaching and for most high-level research positions. Most physicists and astronomers hold Ph.D.s. Seventy percent of the total membership of the American Institute of Physics hold Ph.D.s, 20 percent hold M.S. degrees, and 10 percent hold B.S. degrees (Czujko et al. 1986).

Doctoral students in physics or astronomy can expect to complete an average of three to four years of study beyond the master's degree, including research leading to the completion of a dissertation in their area of specialization.

Related fields—Students with undergraduate degrees in physics or astronomy can elect to enter graduate degree programs in other areas of science to prepare for careers in biophysics, chemical physics, engineering, geophysics, etc. The number of physicists working in careers that combine physics with other sciences or engineering has increased in recent years (U.S. Bureau of Labor Statistics 1986).

Unrelated fields—A physics background can also be combined with education, law, medicine, and a variety of other fields.

Outlook and Salaries

- In 1987, the professional membership of the American Institute of Physics totalled approximately 86,000 (AIP 1987).
- Employment opportunities in physics are expected to grow between 4 and 10 percent through the mid-1990s, more slowly than the average for all occupations (U.S. Bureau of Labor Statistics 1986).
- In the current economy, there will be considerable competition for positions in physics and astronomy. Physics graduates with doctorates will be in greatest demand. Physics majors with bachelor's degrees are not qualified to enter most physicist positions, but many find work as technicians, engineers, computer specialists, and secondary teachers (U.S. Bureau of Labor Statistics 1986).
- The job outlook is brightest for those who expect to work in private industry. If research and development expenditures increase through 1995 as expected, positions will open up. However, little growth is expected in universities and colleges as enrollment numbers stabilize. Individuals interested in academic positions will probably have to wait for existing positions to become vacant. Similarly, government funds are not expected to increase significantly to create many new positions (U.S. Bureau of Labor Statistics 1986).
- In 1984, nearly half of all employed physicists held faculty positions in colleges and universities. Approximately one quarter worked for independent research and development laboratories. Three out of 10 physicists worked in government positions, primarily for the Depart-

ments of Defense and Commerce (U.S. Bureau of Labor Statistics 1986).

- During the late 1970s and early 1980s, an influx of foreign graduate students majoring in physics reversed a decline in physics enrollments in the U.S. The rise in foreign student enrollment also contributed to a substantial increase in the number of women receiving doctorates in physics (Ellis 1986–87).

- In March 1985, the median annual salary for American Institute of Physics members was $44,100. Physicists and astronomers with Ph.D.s, who comprise nearly 75 percent of AIP full-time employed membership, earned a median salary of $46,000. Those with master's or bachelor's degrees earned approximately $40,000 (AIP 1987).

- Salaries vary according to employer, location, and years of experience. The highest median annual salaries were paid by private industry in highly industrialized areas of the Pacific coast and in the Middle Atlantic states. In 1985, AIP members working in industry earned median annual salaries of $48,300–$65,000. Those employed in manufacturing earned slightly higher salaries than those in services. Federally funded research and government positions paid the next highest salaries: $39,000–$68,000. Universities and colleges paid median annual salaries of $29,000–$58,000 (AIP 1987).

- While male physicists continue to earn more than their female counterparts, this disparity has decreased steadily. In 1981, women physicists and astronomers earned 25 percent less than their male colleagues in colleges and universities and 16 percent less than their colleagues in industry and other nonacademic settings. By 1985 this salary gap had narrowed to 12 percent and 10 percent, respectively (AIP 1987).

For More Information

Associations and Organizations

American Association of Physics Teachers, 5110 Roanoke Place, Ste. 101, College Park, MD 20740; 301/345-4200.

American Astronomical Society, University of Delaware, Newark, DL 19711; 202/659-0134. (The society consists of 4,000 astronomers, physicists, and scientists in related fields. Among other projects, the society maintains and distributes information on the status of women in astronomy.)

American Institute of Physics, 335 E. 45th St., New York, NY 10017-3483; 212/661-9404. (AIP is a corporation of national societies in the field of physics. Among other projects, the institute provides information about physics education to students, physics teachers, and physics departments.)

American Physical Society, Commission on the Status of Women in Physics, 335 E. 45th St., New York, NY 10017-3483; 212/682-7341.

Astronomical Society of the Pacific, 1290 24th Ave., San Francisco, CA 94122; 415/661-8660. The society exists to increase public understanding and appreciation of astronomy; disseminate relevant information; sponsor lectures, conferences, and teacher workshops. ASP offers a full catalog of educational materials in astronomy. ASP also maintains the Astronomy News Hotline: 415/661-0500.

Health Physics Society, 1340 Old Chain Bridge Rd., Ste. 300, McLean, VA 22101; 703/790-1745.

Society of Physics Students, 335 E. 45th St., New York, NY 10017-3483; 516/349-7800. (Operated by the American Institute of Physics to promote education for all students and others interested in physics.)

References

American Institute of Physics. 1987. *1985 Salaries: Society Membership Survey.* Education and Employment Statistics Division.

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Ellis, Susan D. 1986–87. *Report: Education and Employment.* American Institute of Physics. Manpower Statistics Division.

National Science Foundation, January 1988. *Women and Minorities in Science and Engineering.* NSF 88-301.

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Additional resource materials, programs, and teaching materials on women and science are listed on pages 75-76.

Program 8
Scientific Careers for Women: Doors to the Future

Program Objectives

This program is designed to help counselors, parents, teachers, and students become more aware of the wealth of career opportunities available in the sciences while examining some of the barriers that discourage young women from pursuing these careers.

Viewers should be able to identify some of the barriers women face, identify misconceptions about women and science, and suggest some strategies that help women succeed in their pursuit of mathematics and science.

Program Summary

While the number of women studying and working in science and engineering has increased dramatically since the 1970s, many high school-age women do not complete the academic preparation necessary for a college major in science or engineering. The narrator quotes Betty Vetter, director of the Commission on Professionals in Science and Engineering, formerly the Scientific Manpower Commission.

> If a young woman does not take a full complement of math and science courses while in high school, she has eliminated herself from 75 percent of all job opportunities.

The program illustrates that career decision making is a complicated process. For young women to be receptive to nontraditional career opportunities, they must possess

- knowledge of the opportunities available to them
- input and support from parents, counselors, teachers, and friends
- a solid academic foundation in mathematics and science

The program examines what happens in the precollege experience of young women that discourages them from pursuing mathematics and science careers. The following women scientists, engineers, psychologists, students, and counselors discuss the barriers that prevent young women from pursuing career opportunities in the sciences.

In order of appearance

- **Judy Clark**, a bioengineering student with a special interest in nuclear medicine
- **Karen Morse**, head of the Department of Chemistry and Biochemistry at Utah State University
- **Judith Davenport**, D.M.D., a dentist practicing in a private clinic in Pittsburgh, Pennsylvania
- **Tanya Atwater**, Ph.D, a geoscientist and faculty member at the University of California–Santa Barbara
- **Nena Menlove**, B.S.E., a civil engineer in Boise, Idaho
- Several unidentified **high school students** from Baton Rouge, Louisiana, and Ann Arbor, Michigan
- An unidentified **chemistry major** at the University of Michigan
- **Barbara Sloat**, Ph.D., director of the *Women in Science* project at the University of Michigan
- **Irene Jones**, a genetic toxicologist at Lawrence Livermore Labs in Livermore, California
- **Pat Cole**, M.S., a computer software manager for Atari, Inc., Sunnyvale, California
- **Jacquelyne Eccles**, Ph.D., a psychologist at the University of Michigan
- **Beth Concoby**, M.P.H, an industrial hygienist for P.P.G. Industries, Pittsburgh, Pennsylvania
- **Janet Ku**, M.S.E., a Ph.D. student in bioengineering at the University of Michigan
- **Meridee Jones-Cecil**, M.S., a seismologist working for the United States Geological Survey in Colorado

- **Gayle Ater**, a Louisiana high school science teacher who was named *Discover* magazine Science Teacher of the Year, 1983
- An unidentified **physics graduate student** at the University of Michigan
- **Bonnie Hausman**, B.S., a computer programmer with the National Oceanic and Atmospheric Administration
- **Letitia Byrd**, M.A., a high school counselor in Ann Arbor, Michigan
- **Gail March**, M.S.E., an electrical engineer at Rockwell International in Troy, Michigan
- **Marta Kindya**, B.S.E., a telecommunications engineer and training supervisor at New York telephone
- **Joyce Essien**, M.D., Director of the Laboratory Program Office at the Centers for Disease Control in Atlanta, Georgia
- **Bonnie Robinson**, B.S., a production geologist for the Superior Oil Company in Denver, Colorado

Barriers Addressed in This Program

The women in this program discuss the following social and psychological barriers that prevent young women from preparing for science careers.

- **Many women perceive women scientists and science careers as unattractive or unfeminine.**

  Several high school students share their perceptions of scientists. One student imagines a scientist to be "an old man with white hair and a little lab jacket." Another comments that scientists are "really quiet, really introverted, really, really intellectual." She also suggests that a scientist is someone who "doesn't get along with people well."

  Several science students and professionals refute the notion that scientists are unattractive or unfeminine. A graduate student mentions her work in a chemistry research laboratory: "It was not considered unfeminine, so to speak, to get your hands dirty." Geologist Tanya Atwater comments: "Geology is so much fun. I love to get dirty and sweaty."

- **Many women believe that scientists aren't people-oriented.**

  Several women scientists react to the notion that scientists and engineers work in isolation. Nena Menlove, an engineer, says: "One of the most important parts of my job is communication, and I think that's why I enjoy construction more than designing."

  "No one should have the vision that a scientist works alone in a dark and lonely place," toxicologist Irene Jones remarks. "All of us work together as a team. There are times when you're alone doing something. But by in large, we're a very large and happy family..."

  Psychologist Jacquelyne Eccles suggests that women are more "person-oriented," more drawn to occupations and service fields that help people in a direct manner. She stresses the importance of informing women students that many science careers offer the opportunity to interact with and serve people.

- **By the time they graduate from high school, many women are academically deficient in mathematics and science.**

  The research conducted by Jacquelyne Eccles and others suggests that young women perceive mathematics as less important and less valuable in terms of their career goals, and this perception is sufficient to persuade them to discontinue taking mathematics and science after the required basic courses.

  Many of the women scientists featured in the program stress the importance of a solid high school background in mathematics and science. "I think that students should take all the mathematics and science they can in high school, whether or not they plan to be scientists," physics teacher Gayle Ater comments. "Most students in high school don't know what they want to be when they grow up, and for that reason I think they should leave all doors open."

- **Many women lack confidence in their ability to succeed in mathematics and science courses.**

  Research suggests that lack of confidence and math anxiety prevent women from enrolling in mathematics and science courses. But the research of Sheila Tobias and others has proven that confidence issues and math anxiety can be dealt with successfully through desensitization treatments, which involve creating a more positive environment for women in mathematics and science courses.

  Several women scientists describe how they coped successfully with their own fears and anxieties in mathematics and science courses.

  Engineer Bonnie Hausman comments: "I figured that nobody else in that class is better

than I am. The fact that I didn't catch on instantly like the rest of the guys in the class didn't bother me that much, because I knew in the end that I would understand it too."

- **Many women perceive a role conflict between having a career in science and being a wife or mother.**

  Most women work outside the home and will continue to do so for most of their lives, whether or not they are married or have young children. Combining roles always means making special arrangements and spending extra energy, but this is true in any career. Careers in science often allow the flexibility and financial freedom to manage career and family successfully.

  Several women scientists discuss the rewards and difficulties of combining their careers with family life. Geologist Tanya Atwater comments: "Very often young women come to me and ask me if it's possible to be a mother and a career person at the same time, and I'm always flabbergasted because no man would ask that question. They assume it will be worked out. And it gets worked out for women too. Most of my women scientist friends have children, and they work it out in amazing different numbers of ways and sometimes it's easy and sometimes it's hard. But nobody wants an easy life. That's boring."

- **In addition to their own misconceptions and concerns about science careers, young women must also contend with discrimination from parents, teachers, counselors, and peers.**

  Jacquelyne Eccles comments: "Some students, girls especially, often meet with active resistance to the suggestion on their part of alternative careers, with career guidance counselors and teachers, and in some cases, parents, actively discouraging them from thinking about these other careers."

  According to Eccles, young women sometimes experience a lack of attention from mathematics and science teachers. In one such case, the girls in a high school science class said that the boys perform the experiments, while they are expected to clean up afterward.

  "What we found," Eccles explains, "was that schools play a very passive role, that schools are not actively discouraging girls, but they are not actively encouraging them."
  Research suggests that parents are more likely to commend female children for their hard work and effort rather than for possession of innate talent or skill in mathematics and science. Parents more often praise sons for their talent and skill when they perform well in these subjects.

  Many of the featured women scientists comment on the influences, both negative and positive, that parents, teachers, counselors, and peers had on their career decisions. They also discuss ways they have managed to overcome the negative effects of subtle and direct discrimination.

Did You Know?

- Women now earn 50 percent of all bachelor's and master's degrees and 33 percent of all doctorates, but their representation in many nontraditional fields, including engineering and some science fields, is significantly below these figures. In engineering, women earned only 13.2 percent of all bachelor's degrees, 9.2 percent of all master's degrees and 4.4 percent of all doctorates in 1982–83. In physical sciences such as chemistry and physics, women earned 27.3 percent of all bachelor's, 21.4 percent of all master's, and 14 percent of all doctorates (Ehrhart and Sandler 1987).

- In 1986 women comprised 44 percent of U.S. employed workers, 49 percent of all employed professionals, but only 15 percent of employed scientists and engineers. In 1986, 1 in 4 scientists was a woman and only 1 in 25 engineers was a woman (National Science Foundation, January 1988).

- While the number of women scientists and engineers is still small, it represents a dramatic increase, rising from 9 percent in 1976 to 15 percent in 1986 (National Science Foundation, January 1988). Employment growth for men scientists and engineers remained at about 6 percent during the same 10-year period.

Number of Women Scientists and Engineers Employed in the U.S.

1976	1984	1986
199,700	512,600	698,600

National Science Foundation, January 1988

Before the Program

1. What image do you hold of a typical scientist? What qualities and attributes do they possess? Are the qualities and attributes you thought of considered to be traditionally feminine or masculine?

2. Can women be successful scientists and engineers?

3. Do most women work outside the home? Can most young women today choose whether not not they will work?

4. What advantages might a career in science have over other kinds of careers?

5. Is it as easy for young women to pursue science and engineering as it is for men?

6. What kinds of factors determine whether a young woman will pursue a career in science or engineering through college?

7. What are the barriers that directly and indirectly block young women from pursuing science and engineering careers?

After the Program

1. How did the high school girls featured in the program describe a typical scientist? ("an old man with white hair and a little lab jacket"; "somebody who was just buried in her work"; "really quiet, really introverted, really, really intellectual"; "doesn't get along with people well")

2. How do the featured women scientists and engineers dispel these stereotyped images of scientists? (Many of the women [Nena Menlove, engineer; Irene Jones, toxicologist; Pat Cole, computer scientist] mention that they work with others and stress that communication and interaction are important aspects of their jobs. Several women [Beth Concoby, industrial hygienist; Janet Ku, bioengineer; Meridee Jones-Cecil, seismologist] mention that their work goals focus on improving and protecting the health and lives of individuals. They are articulate, dedicated, bright women who enjoy their careers, but they also have other interests such as family, friends, and recreation.)

3. How many women today are scientists and engineers? (In 1986, 15 percent of all working scientists and engineers were women, as compared to 9 percent in 1976. Today, more than 1 in 4 scientists are women and 1 in 25 engineers are women. See the Did You Know? section for more relevant statistics.)

4. What factors must be present before a young person can make an intelligent career choice? (knowledge of the opportunities available; support and input from parents, counselors, teachers, and friends; a solid academic foundation) Are all of these factors present for young women when they make career decisions? (Not always. Many young women aren't made aware of or encouraged to pursue the opportunities available to them in science and engineering. Many must contend with subtle and direct discrimination.)

5. What are some of the barriers that directly and indirectly block women from pursuing science and engineering careers? (Many women perceive scientists and science careers as unattractive. Many believe that scientists aren't people-oriented. Many are academically deficient in mathematics and science by the time they graduate from high school. Many women lack confidence in their ability to succeed in mathematics and science courses. Some perceive a role conflict between having a career in science and being a wife or mother. Many must contend with discrimination from parents, teachers, counselors, and peers.)

6. Which individuals have significant influence on the career decisions of young men and women? (counselors, parents, peers, teachers) What kinds of experiences and situations might influence their career choices? (lack of encouragement or unequal treatment in mathematics and science classes; subtle or direct discouragement from counselors, parents, and teachers; teasing from peers)

7. Do most young women believe that mathematics is an important and valuable aspect of their educations? (Studies indicate that girls perceive mathematics as less important and less valuable to their career goals. Subsequently, girls are more likely to drop out of mathematics courses [Armstrong and Price 1982; Haven 1972].)

8. Are young men and women treated equally in mathematics and science courses? (Young women often perceive that teachers pay less attention to them in mathematics and science

courses. There is some evidence to suggest that men and women have different experiences in mathematics courses [Becker 1981]. Other studies clearly indicate that girls frequently meet with resistance from teachers, parents, counselors, and peers when they develop interests in nontraditional careers [Haven 1979; Casserly 1979].)

9. Why is it important to take courses in science and mathematics in high school? (Young women who avoid mathematics and science in high school are often ill-equipped to major in sciences or mathematics in college. Betty Vetter of the Commission on Professionals in Science and Technology says that young women who don't take a full complement of mathematics and science in high school have eliminated themselves from 75 percent of all job opportunities.)

10. How is learning mathematics to prepare for science similar to learning a foreign language before traveling? (Mathematics is a kind of language for science. It enables a student to communicate and interact within the framework of science just as knowing a foreign language enables a traveler to communicate and interact in a foreign country. Students who develop strong foundations in mathematics can apply it to science more easily.)

11. How might young women come to believe that they aren't skilled or talented in mathematics, and that, if they succeed, it is because they try harder than young men? (Subtle forms of discouragement. Parents are more likely to attribute their daughters' successes in mathematics to hard work and effort, rather than skill or talent. Consequently, girls incorporate the notion that they try hard, but aren't actually skilled or talented at mathematics into their self concepts.)

12. Does math anxiety afflict only women? (Both men and women experience math anxiety. Can students successfully overcome math anxiety? (Studies show that men and women can overcome math anxiety through desensitization treatments, which deal with the problem much like clinical psychologists deal with other forms of anxiety.)

13. Can professional women scientists and engineers successfully combine their careers with husbands and children? (Yes, although it often requires making special arrangements and compromising on some aspects of daily life. The women featured often mention the support and help they receive from their husbands. The good salaries many women scientists earn ensure that they can afford good child care.)

14. Do most women work outside the home today? (Almost all women spend a portion of their lives working outside the home. Most women are employed an average of 28 years of their lives.) Do many women with children work outside the home? (Sixty percent of mothers with children under the age of 16 work.) Do most women today choose whether or not they will work? (In many cases, economic circumstances make it necessary for women to work.)

15. What kind of role do most schools play in encouraging young women to pursue mathematics and science? (Studies suggest that most schools play a passive role: they do not actively discourage or encourage young women.)

16. What does it mean to "keep all doors open" for future career choices? (If a young woman avoids or rejects mathematics and science in high school, she has effectively closed some doors to future career opportunities. By establishing a strong academic preparation in high school, including mathematics and science, a woman ensures herself a broader selection of college majors and many more career options.)

Supplementary Materials for Administrators, Counselors, Teachers, and Students

Supplemental Activities

1. Develop a policy regarding sex fairness in your school or school district. Hold a special meeting to discuss strategies for creating an equitable climate for men and women. Inform college recruiters and other guest speakers of your policy.

2. Plan a series of workshops, seminars, or in-services to address issues of sex fairness and equal treatment in your school. Include sessions and activities of relevance to administrators, counselors, curriculum specialists, students, and teachers. For help, contact the EQUALS program at the University of California–Berkeley. EQUALS promotes the participation of women in mathematics and encourages their entry into all occupations through model workshops, classroom projects, teaching strategies, problem solving activities, and other materials. For more information on EQUALS see pages 73-74.

3. Actively recruit women for mathematics and science classes. Schools often play a passive role in the course selection and career decision-making processes of their students. (Studies show that young women are more likely than men to avoid mathematics and science classes, and less likely to be encouraged to enroll.) Emphasize the importance and relevance of mathematics and science classes to students' future career plans.

4. Develop a series of sneak previews: short, fun, motivational mini-courses designed to encourage women to sign up for specific mathematics and science courses. A sneak preview should help women develop enthusiasm for the subject by explaining what topics will be covered, how the subject relates to the real world, and what kinds of college majors and career opportunities are available to those with knowledge and skills in the subject. Liven up the sneak preview with a demonstration, experiment, or videotape.

5. Evaluate your school's career guidance materials and practices to ensure that they promote sex fairness and equality of opportunity for men and women. A bibliography of sex-fair counseling and career awareness materials is included in the EQUALS Handbook. (See pages 73-74 for more information about EQUALS.)

6. Incorporate career education in mathematics and science classrooms as early as possible. Help students see how these subject areas relate to real occupations. (Studies indicate that many young women reject mathematics and science because they believe them to be irrelevant to the personal career goals they have made, often as early as ninth grade. Inadequate career information may give young women false impressions of the irrelevance of mathematics and science in many careers [Becker and Jacobs 1983].)

7. Adopt teaching techniques that improve the mathematics and science achievement of women and men. Successful techniques include more "hands-on" experiences in classrooms and laboratories and the use of cooperative rather than competitive learning and problem-solving methods (Campbell 1986; Burns 1981). More information on successful techniques, programs, and ideas about teaching mathematics are included in the Phi Delta Kappa *Exemplary Practice Series* on mathematics. Contact Phi Delta Kappa, P.O. Box 789, Bloomington, IN 47402; 812/339-1156. The cost is $20.

8. Develop a women in science internship program. Arrange for interested young women in your school to intern with local women scientists in their laboratories and offices. Students will gain hands-on experience and positive reinforcement from their scientist-role models. The University of Michigan sponsors such an internship program and publishes guidelines to help schools develop programs based on this model. For more information contact the Women in Science Program, University of Michigan, 350 S. Thayer St., Ann Arbor, MI 48109 and request *Summer Internships in the Sciences for High School Women, A Model Program at the University of Michigan*, by Barbara Sloat and Catherine DeLoughry.

9. Establish a support group for young women who pursue mathematics and science beyond the basic requirements. The group could take the form of a club such as "Future Women Scientists." Plan confidence-building and motivational activities such as meeting role models and taking field trips to the laboratories or offices of female scientists. The club might publish a science newsletter for the entire school or sponsor special activities such as guest lectures and science fairs.

10. Invite local women chemists, doctors, physicists, engineers, and other science profes-

sionals to participate in a women in science lecture series or career fair at your school. Contact nearby hospitals, industries, universities, and professional organizations to identify potential participants.

11. Organize a big sisters in science program. Invite local women scientists to spend several hours a week acting as mentors to young women in your school. Activities might include visiting the laboratories and work places of the big sisters, designing and participating in research projects, discussing career goals, and other motivational activities. Participants could meet once a month to share their experiences, to report on ongoing research projects, and to participate in field trips and other group activities.

12. Ask the admissions staff visitation team from the state college or university in your area to make a special presentation on nontraditional opportunities for women when they visit your school.

13. Organize a women's tutoring program. Invite women students who have excelled in specific mathematics or science courses in the past to serve as experts in those courses. Experts can provide tutorial assistance, encouragement, and support to women currently taking these courses. Advertise the tutorial, emphasize that students at all levels of performance can benefit from it, and arrange a nonstressful way for interested students to sign-up. Provide a convenient time and place for experts and students to work together.

For More Information

Associations and Organizations

Association for Women in Mathematics, Wellesley College, Wellesley, MA 02181; 617/235-0320. (AWM encourages women to achieve in mathematics and related careers, promotes equal opportunity for women in the mathematical community, maintains speaker's bureau of women serving a wide range of audiences including elementary and junior high school students, publishes bimonthly newsletter.)

Education Development Center/Women's Educational Equity Act Publishing Center. Write or phone the EDC/WEEA Publishing Center, 55 Chapel St., Newton, MA 02160; 800/225-3088 (toll-free) or 617/969-7100 within Massachusetts. (In 1974, Congress passed the Women's Educational Equity Act (WEEA) to promote educational equity for girls and women. The U.S. Department of Education has provided funds to develop a variety of relevant materials under this act. The Education Development Center, in collaboration with the Center for Research on Women at Wellesley College, reviews, publishes, and distributes the material funded under WEEA.)

EQUALS, Lawrence Hall of Science, University of California, Berkeley CA 94720; 415/642-1823. (EQUALS promotes participation of women in mathematics and encourages entry into nontraditional occupations and provides a full range of resources such as model workshops, problem-solving, sex-fairness, and career materials for educators, parents, and others.)

Math/Science Network, Math/Science Resource Center, Mills College, Oakland, CA 94613. (Math/Science Network promotes women's participation in mathematics and science, acts as a planning resource for organizations such as the National Science Foundation and the National Council of Teachers of Mathematics, and sponsors programs and conferences for teachers and students throughout the U.S.)

National Council of Teachers of Mathematics, 1906 Association Dr., Reston, VA 22091; 703/620-9840.

Project on Equal Education Rights (PEER) of the NOW Legal Defense and Education Fund, 1413 K St. NW, 9th Floor, Washington, DC 20005; 202/332-7337. (PEER works to end school practices, policies, and attitudes that limit children's choices and ability to learn.)

Women and Mathematics Education, Education Department, George Mason University, Fairfax, VA 22030. (WME emphasizes the need for elementary and secondary programs to reverse female avoidance of mathematics, and works to effect change within the mathematics education community.)

Publications and Resource Guides

The following resources are available from EQUALS, Lawrence Hall of Science, University of California, Berkeley, CA, 94720; 415/642-1823. Make checks payable to The Regents, University of California.

- *EQUALS Handbook.* Sex-fair mathematics instructional materials for teachers and counselors at the elementary and secon-

dary levels. Useful in the classroom and in workshop or inservice planning. Cost: $9.50 (includes shipping and handling).

- *The Family Math Book.* A book designed to help parents help their children learn and enjoy mathematics. The book provides activities appropriate for children ages five to 18, covering topics such as measurement, logical reasoning, geometry and spatial thinking, probability and statistics, estimation, and arithmetic. Cost $17 (includes shipping and handling).
- *I'm Madly in Love with Electricity and Other Comments About Their Work by Women in Science and Engineering.* A career book that features 70 women scientists, engineers, and mathematicians talking about their work and opportunities in their fields. Illustrated with many photographs of the women at work in their laboratories and offices. Cost: $2.50 (includes shipping and handling).
- *Math for Girls and Other Problem Solvers.* Curriculum for Lawrence Hall of Science course, "Math for Girls," with student activities and game sheets. Designed for elementary and secondary students. Cost: $8.50 (includes shipping and handling).
- *SPACES: Solving Problems of Access to Careers in Engineering and Science.* A collection of 32 mathematics and career classroom activities designed to help students develop problem-solving skills while learning about mathematics-based fields of study and work. Designed for students in grades 4–10. Cost: $11 (includes shipping and handling).
- *We All Count in Family Math.* A 17-minute film showing scenes from several Family Math classes taught under the direction of the Lawrence Hall of Science at the University of California–Berkeley. The video demonstrates activities parents and children can do together in family math. Available for rental or purchase. Rental fee: $27. Purchase of 1/2" VHS or BETA: $62. (Both prices include the cost of shipping and handling.)

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Haven, E. W. 1972. Factors Associated with the Selection of Advanced Academic Courses by Girls in High School. (ERIC: Ed. 062 173).

National Science Foundation. January, 1988. *Women and Minorities in Science and Engineering.* NSF 88-301.

Additional Resources

Instructional Materials

Commission on Professionals in Science and Technology. *Opportunities in Science and Engineering.* Chartbook or slides and audiocassette tape available from the Commission on Professionals in Science and Technology, 1500 Massachusetts Ave. N.W., Ste. 831, Washington, DC 20005; 202/223-6995.

Education Development Center. The following materials are available from the Education Development Center, 55 Chapel St., Newton, MA 02160; 800/225-3088.

- *Sandra, Zella, Dee and Claire: Four Women in Science.* Grade level 7-12. Film.
- *Count Me In: Educating Women for Science and Math.* Videocassette.
- *Equality in Science: Formula for Changing Sex Bias. Sex Stereotyping in Education.* Audiocassette and guide.
- *How High the Sky? How Far the Moon?* Grade level K–12. Curriculum resource with four audiocassettes.
- *Sex Stereotyping in Math Doesn't Add Up.* Audiocassette and guide.
- *The Math-Science Connection: Educating Young Women for Today.* Film or videocassette for teachers, parents, and community leaders.
- *Tuggar War.* Film (engineering).

Guidance Associates, Inc. *Challenging Careers: New Opportunities for Women.* Catalyst. Filmstrip and guide available from Guidance Associates, Inc., Communications Park, Box 300, White Plains, NY 10602.

Modern Talking Pictures. *Science: Women's Work.* Film available from Modern Talking Pictures Service, 5000 Park St. North, St. Petersburg, FL 33709.

National Women's History Project. Numerous resources for curriculum and project ideas. Contact National Women's History Project, Box 3716, Santa Rosa, CA 95402; 707/526-5974.

Research Triangle Institute. *Exploring Careers in Science and Engineering.* Slides, audiocassette, posters, activity guide. Available from Iris Weiss, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709.

Thomas, John W. *Making Changes: A Futures-Oriented Course in Inventive Problem Solving.* Available from ETC Publications, Palm Springs, CA 92263.

University of Kansas. *COMETS: Career-Oriented Modules to Explore Topics in Science.* Twenty-four modules including biographical sketches of women in science careers and accompanying language arts activities for junior high school-age students. Available from the Department of Curriculum and Instruction, University of Kansas, 205 Bailey Hall, Lawrence, KA 60045. ERIC: 226-984-1983.

Publications

American Association for the Advancement of Science. *Bibliography on Women in Science, Engineering, and Mathematics.* Available from the American Association for the Advancement of Science, 1776 Massachusetts Ave. N.W., Washington, DC 20036.

American College Testing Program. *Women in Science and Technology: Careers for Today and Tomorrow.* Available from American College Testing Program Publications, P.O. Box 168, Iowa City, IA 52240.

Center for Sex Equity in Schools. *Women, Math and Science: A Resource Manual.* 1982. Available from the Center for Sex Equity in Schools, 1046 School of Education, University of Michigan, Ann Arbor, MI 48109.

EQUALS. *An Annotated Bibliography to Assist Elementary and Secondary School Teachers in Sex-Fair Counseling and Instruction.* Available from EQUALS, Lawrence Hall of Science, University of California, Berkeley, CA 94720.

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U.S. Department of Labor. Bureau of Labor Statistics. *Occupational Outlook Handbook*. Washington, D.C.: Government Printing Office. Revised biennially.

Organizations and Associations

American Association for the Advancement of Science. Library, 1333 H St. N.W., Washington, DC 20005; 202/326-6400.

_____. National Network of Minority Women in Science, 1776 Massachusetts Ave. N.W., Washington, DC 20036.

_____. Office of Opportunities in Science, 1776 Massachusetts Ave. N.W., Washington, DC 20036.

Association for Women in Mathematics, Women's Research Center, Box 178, Wellesley College, Wellesley, MA 02181; 617/235-0320.

Association for Women in Science, 2401 Virginia Ave. N.W., Ste. 303, Washington, DC 20037; 202/833-1998.

Commission on Professionals in Science and Technology, 1500 Massachusetts Ave. N.W., Ste. 831, Washington, DC 20005; 202/223-6995.

Mathematical Association of America, 1529 18th St. N.W., Washington DC 20036; 202/387-5200.

National Research Council: Committee on Education and Employment of Women in Science and Engineering, JH-710, 2101 Constitution Ave. N.W., Washington, DC 20418; 202/334-2000.

National Science Foundation, 1800 G St. N.W., Washington, DC 20550; 202/357-7748.

Women and Mathematics Education (WME), Department of Education, 3307 Robinson, George Mason University, 4400 University Drive, Fairfax, VA 22030; 703/323-2421.

Competitions

Science Olympiad—a competition for junior high school-age students focusing entirely on scientific projects. For information contact Dr. Gerald Putz, Director, Science Olympiad, Macomb Intermediate School District, 44001 Garfield Road, Mt. Clemens, MI 48044.

Future Problem Solving—a national interschool program that encourages students to think divergently about social problems and about the uses of technologies to solve them. For information contact Anne B. Crabbe, Future Problem Solving Program, Coe College, Cedar Rapids, IA 52402; 319/299-8688.

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